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THE WHITE STAR LINER ADRIATIC.

The *Adriatic,* which left Liverpool on her maiden voyage May 8, arrived in New York May 16. The new vessel has been designed and constructed on absolutely safe lines, guided by previous experience and the highest technical knowledge, while at the same time the latest improvements have been introduced to make her a perfect instrument in the development of international intercourse and commerce between the two great hemispheres. While making the voyage across the Atlantic at a good speed it is confidently anticipated that the *Adriatic* will be, in nautical parlance, "as steady as a rock" under all conditions, and, thanks to her good sea-going qualities and the extremely comfortable character of her appointments, the pleasures of ocean travel will be greatly enhanced.

THE IMMENSE SIZE OF THE ADRIATIC IS HERE APPARENT. NOTE THE SHEER STRAKE RIVETING.

In the endeavor to add to the attractiveness of the vessel and minister to the comfort of ocean travelers, a number of new features have been introduced, including a gymnasium, with the usual mechanical apparatus; an electric elevator, running from the first-class entrance on the boat deck to the dining saloon on the upper deck, the elevator thus serving four decks, viz., upper deck, promenade deck, upper promenade deck, and boat deck. Then, the seating arrangements in the first-class dining saloon are in the popular restaurant style, with small tables studded over the room, instead of the usual long fore-and-aft tables; and an orchestra is carried. The most notable innovation, however, is the provision in this ship of Turkish baths, consisting of the usual hot, temperate and cooling rooms, shampooing rooms, plunge bath and massage couches. There are also electric baths provided.

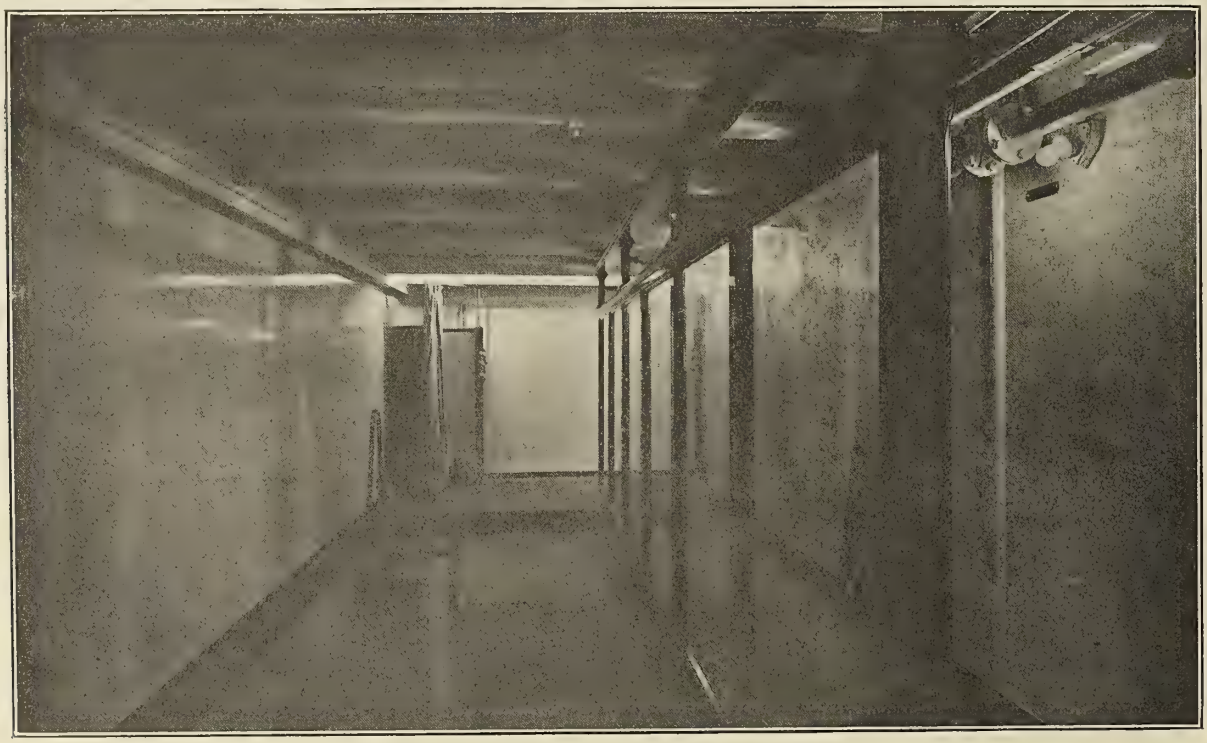
The *Adriatic* is 725 feet 9 inches long, 75 feet 6 inches beam, and about 50 feet deep; gross tonnage nearly 25,000, and displacement over 40,000 tons. The double bottom, extending the whole length of the ship, is a special element of safety. The ship has nine steel decks, and is divided into twelve watertight compartments. The total number of steel plates used in the construction of the hull is almost 20,000, and the rivets are estimated at nearly 2,500,000 in number. The cables are 3⅜ inches in diameter and weigh about 90 tons; the anchors weigh about 8 tons each.

The general arrangements of the ship are similar to the *Baltic* and other vessels of this type, a continuous shade deck running fore and aft, with three tiers of deckhouses and three promenade decks above them. On the boat deck are situated the first-class lounge, the first-class reading and writing room, and the first-class smoke room. On the upper promenade deck and the promenade deck are arranged the large deck state-rooms, and a further

attraction is a large number of single berth rooms, which will be much appreciated by the traveling public. The first-class dining saloon is on the upper deck, and all the first-class accommodation is arranged amidships. Immediately abaft the first-class is the second-class accommodation, included in which are a comfortable dining saloon, with nearly 300 seats, smoke room, and also a ladies' room. The second-class saloon is an exceptionally fine room, extending the full width of the ship. The third-class passengers are provided for abaft the second-class, and to a limited extent at the forward end of the vessel. A great feature in this accommodation is the large number of two, three and four-berth cabins, and the commodious and comfortable dining rooms fitted with tables and revolving chairs.

A visitor to the *Adriatic* cannot fail to be impressed with the strength, luxury and roominess that are everywhere apparent. The amount of "head room" is, perhaps, the most striking. The size of the entrances, apartments, etc., as well as the spaciousness of the promenades, must be seen to be appreciated. The state-rooms are lofty, well lighted, well ventilated apartments, while it will be seen that "over-elaboration," so frequent in ship decoration, has been carefully avoided, while at the same time each apartment has a quiet but rich and symmetrical beauty that is very restful and pleasing to the eye.

The first-class dining saloon is a handsome apartment. Situated on the upper deck, it extends the full width of the ship. It is exceptionally lofty and airy, and contains seating accommodation for about 370 people. It is paneled in the stately fashion of the time of Charles II, and is painted chastely and simply with a delicate and ivory-like white; the gold, which is a time-honored adornment of other saloons, being here strictly confined to the metal fittings. Over the middle of the room is a dome filled with leaded glass, white and the palest yellow in color, and under it are paintings of scenes in Switzerland and Italy, the Yellowstone and the Rhine, to remind the diners of happy hours spent in these playgrounds of the world. An opportunity for music is afforded by a fine piano, whose case is beautified with charming and graceful figures inlaid in light woods on the oak of which it is composed. An important feature in the saloon is the new ar-



THE PLUNGE IN THE TURKISH BATH EQUIPMENT OF THE WHITE STAR LINER ADRIATIC.

the bed furniture, lounges, wardrobes and toilet equipments are all excellent. The enormous beam of the vessel and the height between the various decks have made it possible to provide rooms of exceptional size, and the decoration of the various state-rooms is well in keeping with the traditions of the line.

The most luxurious style is, of course, to be seen in the accommodation for the first-class passengers, for whom a large number of separate and distinct suites of apartments are provided, consisting of state-room, bath-room, etc. These rooms have extra wide beds, also writing tables and wardrobes, and are upholstered in blue moquette, the decoration consisting of small white paneling, the ceiling lincrusta—all white. The other first-class rooms are similarly decorated and upholstered. The first-class entrances are panelled in oak, with ceilings of special design—flat white—and the first-class passages have polished oak dado, with white paneling above. The principal feature in the decorations, however, is the treatment of the chief public rooms in the vessel, viz., the first-class dining saloon, the reading and writing room, the lounge and the smoking room. The illustrations give some idea of the style of decoration and furnishing of two of these rooms, and rangement of the tables, which, in conjunction with the artistic and effective decoration, the domed skylight and the orchestra, will make this a perfectly ideal saloon. The comfort of the passengers will also be enhanced by a special arrangement of the portholes by which they will be able to enjoy the advantages of the fresh sea air without being subjected to drafts.

On the boat deck is the reading and writing room, a charming apartment, which might have been provided for comfort and delight on land. We are nowhere forced to remember the fact that the sea is outside and all around us. The windows, as spacious as in an ordinary house, are filled with leaded glass, and we almost expect on glancing around them, to see a cheerful expanse of park; but we may comfort ourselves for that disappointment by stretching our limbs on luxurious chairs or settees around a very home-like fireside. The walls are decorated in Adam's fashion, with delicate ornaments in low relief, inclosing oval panels filled with paintings of the airy and graceful kind which Bartolozzi and Cipriani made familiar to our great grandmothers. Shaded lamps on the walls and ceiling afford a light which is efficient, yet not glaring. The furniture is in inlaid birch.

The lounge, also on the boat deck, is dedicated to the cult of the idler. The oak paneling of the apartment is restful to the eye, and the ceiling paneling is well worthy of notice. A large and well-selected library invites recreation or study. Writing tables afford an opportunity for correspondence, and the comfortable sofas with which the room is amply furnished, the work tables provided for the industrious, the cozy corners for intimate conversation, and the card tables for those to whom bridge appeals, complete the furnishings. The windows contain in stained glass effigies of poets, painters, dramatists and philosophers.

In the smoke room (also on this deck) cozy comfort is the keynote of the decoration and furnishing. The walls are hung with stamped leather and adorned with pictures which recall some stirring episodes in English naval history. The seats are deep and luxuriously upholstered, of a kind to invite the smoker to lazy enjoyment. The rich and mellow tone of the stained glass are in oak. The third-class dining and smoking rooms are comfortable apartments, with white framing and teak dado, a feature in these rooms being the revolving chairs.

It will be seen that the accommodation for 3,000 odd souls who will make up the full list of human beings on board the *Adriatic* will be everything that could be desired. Having such large cargo-carrying capacity, the ship is fitted with winches and other loading and discharging arrangements of the latest and most efficient type. There are large refrigerating chambers for the carriage of chilled beef, the machines for working them being on the CO_2 principle. There is also an electric winch provided specially for the rapid and noiseless handling of baggage and stores. A Marconi house, with wireless telegraph apparatus, is fitted on the boat deck aft; and in addition, the ship is fitted with a submarine signaling apparatus (Submarine Signal Company, Boston, Mass.), by which means the navigators can become aware in

THE MAIN DINING SALOON OF THE ADRIATIC IS FITTED WITH SMALL TABLES, NONE SEATING OVER TWELVE.

windows affords a light in which the mahogany seats with their carving and their brown leather coverings fairly glow with a somber magnificence of coloring.

There is a barber's shop in the first-class accommodation, fitted up in the usual luxurious style, and the inquiry office is an attractive and useful apartment in the main entrance on the promenade deck. The second-class state-rooms are decorated in white paneling, and both the first and second-class rooms have Brussels carpets. The second-class smoke room is done in oak framing with panels of oak, drapery design. It is upholstered in leather; furniture and dado, walnut. The second-class ladies' room is in satinwood, with panels inlaid; furniture and dado, mahogany. Both this room and the second-class smoke room have stained glass shutters and ceiling lincrusta; parquetry floor. The second-class saloon is in white and gold, mahogany furniture, and lincrusta ceiling. Both the ladies' room and saloon are upholstered in moquette. The second-class lounge is paneled in oak, with furniture of oak, easy tub chairs, etc. The second-class entrance is in oak and white. All first and second-class staircases foggy weather of their proximity to similarly fitted lightships in narrow waters, thus insuring a correct course being kept.

The engines consist of two sets of the quadruple-expansion type, arranged on the Yarrow-Schlick-Tweedy balanced principle, which has been so successful in eliminating vibration. The cylinders are respectively 35½, 51, 73½ and 104 inches in diameter, with a common stroke of 63 inches. In each case the high-pressure cylinder is located forward, with the second intermediate next, then the low-pressure, and the first intermediate. The low-pressure cylinders have slide valves fitted with assistant balance cylinders. All the others have piston valves, two for the second intermediate and one for each of the others. The engine spaces, however, and those who work in them, are isolated from the passenger quarters, so that to the ordinary passenger the only evidence of the mighty power which drives the vessel will be the smoke issuing from the funnels. In addition to the propelling machinery, there is an enormous amount of auxiliary machinery —the Brown steering engines, the electric light machinery, the refrigerating machinery, and the deck machinery are all of the

latest and most approved type. The high-pressure piston rods and valve spindles are fitted with metallic packing furnished by the Beldam Packing & Rubber Company, London.

The *Adriatic* was built by Harland & Wolff, of Belfast. She is on the new Southampton (Wednesday) service of the White Star Line. On her maiden trip, the steamer covered 2,896 nautical miles in 7 days 1 hour 45 minutes, or at the rate of 17.02 knots.

THE LIBRARY OF THE ADRIATIC IS A SPACIOUS APARTMENT, DECORATED IN TASTEFUL SIMPLICITY.

Coal Tar Paint.

There is a general belief that the acids in coal tar are injurious to iron or steel, and it is commonly supposed that they can be neutralized by the addition of lime. It is a well known fact that raw coal tar is practically non-drying. This material has been used to some extent on the bottom of vessels operating in waters of the Gulf of Mexico, and in particular has been applied to the bottom of the floating dry-dock at the New Orleans naval station, in order to get an idea as to its value for under-water work. A number of experiments were performed with the intention of producing such a mixture as might serve the purpose of protecting the bottoms of the ships from marine growths common in tropical waters, while, at the same time, having no injurious effect upon the material of which the hull is constructed.

The proportions of the mixture used are quite variable, depending upon the original consistency of the tar, the use for which the mixture is intended, and the climate in which it is used. Tests were made by the government chemist at the Washington navy yard, and the proportions used by volume for the New Orleans mixture are eight of coal tar to one each of Portland cement and kerosene oil; while a mixture for use at Annapolis contained sixteen parts of coal tar to four of cement and three of oil. The method of mixing consists in first carefully stirring the Portland cement into the kerosene oil, forming a creamy paste. This mixture is then carefully stirred into the coal tar. For best results it should be freshly mixed and kept well stirred. This paint was applied on old leaky tin roofs at the Naval Academy, and resulted in making them watertight. On some of the worst places, the expedient was adopted of applying a coat of the paint and then stretching muslin over the wet paint. After this had dried, an additional coat of paint was applied over the muslin. The results are said to have been very satisfactory.

This coal tar paint is said to stick well to galvanized iron and to thoroughly cover it. The cost of the paint varies from 10 to 15 cents per gallon, as compared with a cost of 80 cents to $1 per gallon for a clear linseed oil paint. The latter, of course, has no durability in salt water or in a very salt atmosphere, on account of the solvent action between the salt and the linseed oil. The tar paint, however, is quite stable and durable under these conditions.

Red lead paint furnishes an exception with regard to durability of the ordinary linseed oil paint. The latter is dried by atmospheric oxidation from the outside, this action being assisted by the dryers or oxidizers added to the paint, and whose ultimate effect is the shortening of the life of the paint. The red lead paint, on the other hand, is dried by the oxidizing action of the red lead itself, and the resultant coat resembles to some extent an amalgam, and is very hard and durable.

A series of experiments on the floating dry-dock at New Orleans gave as best results in red lead paint a mixture composed of 100 pounds of red lead, 20 pounds of white zinc, 5 gallons of raw linseed oil and 3¾ pints of turpentine japan. It was found that this compound should be used on the same day it is mixed, and that if it is passed through a common hand mill after being mixed by stirring, it will be all the better. For three-coat work on a clean new surface, the mixture above mentioned would be used for a third coat, the first and second having respectively 60 and 80 pounds of red lead in place of 100 pounds. The white zinc prevents the paint from crawling, and the raw oil is used in order that the intense drying properties of the red lead may not operate too quickly. The glaring red color may, without injury to the paint, be modified by the addition of a slight amount of lamp black.

APPROXIMATE FORMULÆ FOR DETERMINING THE RESISTANCE OF SHIPS.*

BY A. W. JOHNS, R. C. N. C.

One of the most important problems in ship design is the determination of the power required for the propulsion of the vessel at a given speed. To those designers who have a tank in which a model of the ship can be run, or who are in possession of data obtained from such a tank, the problem is not difficult; but to the majority of designers, who have no such means available, the problem is a somewhat difficult one, especially in the case of a ship of novel form or dimensions.

It is therefore rather remarkable that but little can be found in our transactions, or in our text books, as to the best means to be adopted in such cases to obtain even an approximate solution of the problem. Foreign text books, on the other hand, generally contain many approximate formulæ by which the resistance and horsepower of a ship can be calculated, but in nearly all cases the leading particulars of the ships from which these formulæ were obtained are omitted. The use of such formulæ under these conditions becomes rather a danger than a help to the designer. The purpose of this paper is to bring to notice some of these formulæ, and to show comparisons of the results given by them and those obtained from experiments on models.

Before doing this, however, it is necessary to notice the method commonly employed by designers to obtain the indicated horsepower for a given ship at a given speed, that is, by the use of Admiralty constants. It is almost unnecessary to remark that there are two such constants, one involving the immersed area of midship section, and the other the displacement, speed, and indicated horsepower. The latter constant is the one usually employed, being algebraically expressed by the quantity—

$$\frac{D^{\frac{2}{3}}\ V^3}{\text{I. H. P.}}$$

For the earliest steamships, in which speeds were relatively small and nearly all the resistance was due to skin friction, the quantity thus obtained had a very nearly constant value at all speeds, but with the comparatively high speeds now obtained the quantity is a very variable one. It is worthy of note, in connection with the Admiralty constants, that with the same efficiency of propelling apparatus, and also assuming the whole of the resistance to conform to the law of comparison, the constant will be the same for similar ships at corresponding speeds. As, however, the whole of the resistance does not conform to the law of comparison, it is not difficult to see—with the same reservation as to the efficiency of propelling machinery—that the employment of the Admiralty constant at corresponding speeds in similar ships will give too small a result in passing from a large to a small ship, and too great a result in passing from a smaller to a larger ship.

The disadvantage attending the employment of the Admiralty constant is that one cannot separate the performance of the ship itself from that of the propelling apparatus. A good form of ship with an unsuitable screw will give the same constant as a bad form of ship with a good screw. The two cannot by any means be separated, and this is a serious drawback, for the designer cannot say from the results of trials if his ship is the best form he could have adopted, or if the screw is the best which he could have employed. To separate the performances of the two it is necessary to know the resistance of the ship alone, and this is the purpose of the approximate formulæ, which have been given from time to time. It is to be remarked in connection with the Admiralty constant that a similar method of obtaining the power of a ship has been used by the French naval authorities; but, with the recent establishment of an experimental tank in Paris, this method of estimation will drop into disuse, as it has at the British Admiralty.

Passing now to approximate formulæ for the calculation of resistance, it will be found that such formulæ generally consist of two terms. The first term involves the frictional or skin resistance, and is of the form $R = f\ S\ V^{1.83}$ where f is the coefficient of friction, suitable for the state of the bottom and length of vessel, S is the wetted surface, and V is the speed. The values of f given by Tidemann's experiments are generally recommended, these being from 3 to 5 percent greater than those determined by the late William Froude. The second term of the formulæ is that involving the wave resistance, or, better still, the residuary resistance. It is this term with which this paper is particularly concerned.

MIDDENDORF'S FORMULA.

An approximate formula which is found in nearly all foreign text books is that due to Middendorf, and was first made public in 1879. I have been unable to see the work in which it was originally published, but for English units it takes the following form*:

$$\text{Residuary resistance in lbs.} = \frac{0.428\ M\ V^{2.5}}{\sqrt{1 + e\left(\frac{L}{B}\right)^2}}$$

where M is the immersed midship section in square feet,
V is the speed in knots,
L is the length in feet,
B is the breadth in feet,
and e is a coefficient varying with the prismatic coefficient and given by the following table:

Prismatic Coefficient.	Value of e.	Prismatic Coefficient.	Value of e.
0.70 and under.	2.	0.82	1.42
0.72	1.98	0.84	1.18
0.74	1.93	0.86	0.90
0.76	1.85	0.88	0.55
0.78	1.75	0.90	0.02
0.80	1.62		

It will be seen at once that this formula does not conform to

*Read before the Institution of Naval Architects, March 22, 1907.

*See *Théorie du Navire*, Vol. III, page 511, Pollard and Dudebout; or *Die Schiffmaschine*, Busley.

TABLE I.

Length, 250 feet Displacement, 760 tons Prismatic coefficient, 0·85			210 feet 620 tons 0·83		162 feet 449 tons 0·78		85 feet 254 tons 0·71		145 feet 700 tons 0·63			380 feet 4,740 tons 0·58		
Speed	Calculated	Model	Calculated	Model	Calculated	Model	Calculated	Model	Speed	Calculated	Model	Speed	Calculated	Model
Knots	Tons	Tons	Tons	Tons	Tons	Tons	Tons	Tons	Knots	Tons	Tons	Knots	Tons	Tons
6	·157	·165	·165	·145	·187	·13	·53	·16	8	1·24	·21	15	11·7	4·5
7	·230	·225	·243	·205	·275	·195	·77	·33	9	1·66	·81	16	13·7	6·0
8	·322	·295	·340	·295	·384	·28	1·08	·64	10	2·16	1·23	17	16·0	7·4
9	·432	·525	·455	·495	·515	·46	1·45	1·38	11	2·75	1·9	18	18·5	9·2
10	·562	1·06	·590	1·100	·67	1·34	1·88	3·3	12	3·42	3·52	19	21·1	11·45

the law of similarity, for at corresponding speeds the residuary resistances for similar ships will vary as the 1 1/12 power of the displacement, instead of the first power. If true, therefore, for one particular size of vessel, it will not be true for similar vessels at other displacements. Bearing in mind the date of publication (1879), it can be supposed that this formula should apply to comparatively small vessels at low speeds. In Table I the vessels taken are not large, and the speeds are comparatively low. The table shows the resistances obtained by this formula compared with those obtained from model experiments, the leading particulars of the ships being given.

The results show that, except in the first and second cases, which are vessels with considerable lengths of parallel middle body, the calculated results are greatly different from the model results. It appears from the first example given, and also from other examples which have been taken, that this formula is applicable only to vessels of large prismatic coefficients, below 700 tons displacement, and then only at low speeds. For vessels of moderate displacements, the results are generally about twice the experimental results.

MODIFIED MIDDENDORF FORMULA.

In a recently published book* a slightly different form has been given to the formula of Middendorf. For English units it takes the following form:

$$R = \frac{A \times 0.039 \times M \times V^{2.5}}{\sqrt{1 + C \times \left(\frac{L}{B}\right)^2}}$$

where $C = 4.7 - 0.32 \times \frac{L}{B}$

and A varies with the ratio $\frac{L}{V^2}$ according to the following table:

Value of $\frac{L}{V^2}$.	Value of A.	Value of $\frac{L}{V^2}$.	Value of A.	Value of $\frac{L}{V^2}$.	Value of A.
.08	24.5	.40	17.0	.75	11.75
.10	23.9	.45	16.0	.80	11.3
.15	22.5	.50	15.2	.85	10.9
.20	21.2	.55	14.3	.90	10.6
.25	20.0	.60	13.6	.95	10.3
.30	19.0	.65	12.9	1.00	10.1
.35	18.0	.70	12.3	1.05 and above.	10.0

From the values given for $\frac{L}{V^2}$ it will be seen that this formula is applicable to very high speeds, such as those obtained by torpedo vessels and other small fast craft. Since for similar vessels at corresponding speeds the quantity $\frac{L}{V^2}$ is constant, this formula, like the preceding one, does not conform to the law of comparison. For ordinary vessels the results given by this formula are somewhat smaller than those given by the first, but for vessels of moderate displacement they are generally still much greater than those given as the result of model experiments. Table II below shows side by side the calculated and experimental results for six vessels. The last three are destroyers, and in these cases the effective horsepower is given in place of the resistance.

From this table it will be seen that for the first two vessels the calculated results are generally very different from the model results. In the third case, where the displacement is very much less than those of the first two cases, the results are somewhat closer. In each of the three cases, there is an agreement at one speed, but there is no regularity as to the speed at which this occurs. In the fourth and fifth cases taken the results are in fairly close agreement, but in the sixth vessel there is a wide divergence in the results. From these and other cases which have been taken it would appear that this formula gives very fair approximations to the resistance of vessels of displacements of from 300 to 600 tons with $\frac{\text{beam}}{\text{draft}}$ ratios of from 3.6 to 3.8, at their highest speeds. For large and fast vessels the calculated results generally are much greater than the experimental results. As in the first form of the formula quoted, the second form appears to be also applicable to vessels of about 700 tons displacement with high prismatic coefficients and at relatively low speeds. For such vessels the second form gives slightly better results than the first. It is to be remarked that in high-speed vessels, where the length is generally from ten to twelve times the breadth, the formula can be written:

$$\text{Residuary resistance in pounds} = \frac{A \times 0.039 \times V^{2.5}}{\frac{L}{B}\sqrt{C}}$$

Although, as has been pointed out, the above formulæ do not conform to the law of comparison, they may be used for larger vessels than those of the displacements stated above by first reducing the larger vessels to the displacement for which the formulæ give good results, and then using the law of comparison on the calculated results to obtain those for the larger vessels.

ADMIRAL FOURNIER'S FORMULA.

Another approximate formula which has been proposed is that given by Admiral Fournier. It differs from those usually given in that it consists of one term only, which gives the total resistance, and is made to depend entirely on the coefficient for surface friction. The formula is extremely complicated. Admiral Fournier, in publishing, gave the results as calculated for a number of models of French warships compared with the results obtained by towing models one-sixteenth the actual size of the

*Wilda, *Marine Engineering*, 1906.

TABLE II.

Length, 340 feet Breadth, 57½ feet Displacement, 9,000 tons			417 feet 75 feet 14,800 tons			386 feet 40 feet 2,900 tons			Length, 227 feet Displacement, 375 tons $\frac{\text{Beam}}{\text{Draft}} = 3.6$			235 feet 390 tons 3·8		225 feet 560 tons 3·2		
Speed	Resistance		Speed	Resistance		Speed	Resistance		Speed	Effective H. P.		Effective H. P.		Speed	Effective H. P.	
	Calculated	Model		Calculated	Model		Calculated	Model		Calculated	Model	Calculated	Model		Calculated	Model
Knots	Tons	Tons	Knots	Tons	Tons	Knots	Tons	Tons	Knots					Knots		
12	11·8	4·9	15	31·1	14·0	22	15·7	11·3	15	135	110	140	90	15	172	230
13	14·4	7·0	16	36·5	17 8	23	18·5	14·4	20	510	640	525	570	17	304	390
14	17·3	11·4	17	42·6	21·9	24	21·6	19 2	24	1,180	1,490	1,230	1 370	19	520	660
15	20·6	16·1	18	49·2	31·2	25	25·3	25·2	28	2,270	2,290	2,380	2,170	21	830	1,260
16	24·2	22·6	19	56·2	56·4	26	29·4	32·7	30	3,010	2 820	3,160	2,550	23	1,260	2,020
17	28·2	40.8	20	63·8	91 6	—	—	—	—	—	—	—	—	25	1,860	2.750

vessels. This table is given in the appendix† and shows a remarkable agreement between the two sets of results. When applied to actual vessels, however, the results are in most cases greatly different from the results obtained from models. This will be seen from the following table:

TABLE III.

Battleship of 15,000 tons			Battleship of 14,000 tons			Cruiser of 5,600 tons		
Speed, Knots	Effective H. P.		Speed, Knots	Effective H. P.		Speed, Knots	Effective H. P.	
	Calculated	Experimental		Calculated	Experimental		Calculated	Experimental
10	1,265	1,000	14	3,300	2,580	16	12 500	2,190
12	2,310	2,100	16	5,200	4.050	20	46,000	5,200
14	3,900	2,800	21	14,400	14,880	Cruiser of 3,000 tons		
17	7,820	5.650	—	—	—	14	1,510	930
20	15,000	17.500	—	—	—	16	9,300	11,400

Except in the first two cases the results are widely different from the model experiments, and as a serious formula in the calculation of the resistance of ships it is, therefore, of little value.

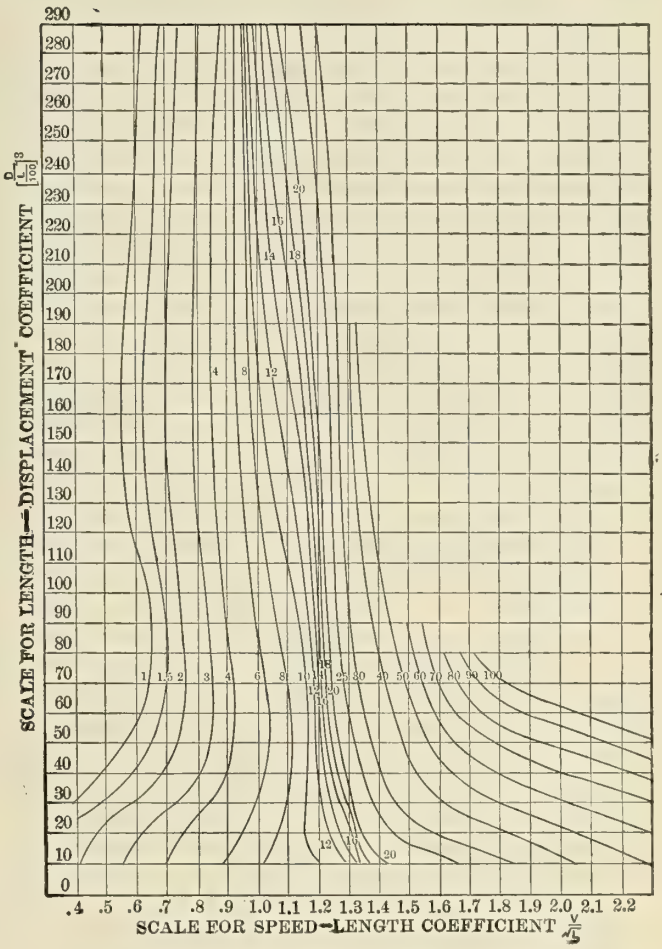
MR. D. W. TAYLOR'S FORMULA.

The next formula to be considered is that given by Mr. D. W. Taylor,* which takes the form:

$$\text{Residuary resistance in pounds} = \frac{12.5\ b\ D\ V^4}{L^2}$$

where b is the block coefficient;
D is the displacement in tons;
V is the speed in knots;
L is the length on the waterline in feet.

The formula is stated to be applicable only to speeds for



TAYLOR'S CURVES OF RESISTANCE, FROM MODEL EXPERIMENTS.

TABLE IV.

Battleship of 15,000 tons				Cruiser of 2,900 tons Length, 385 ieet				Destroyer, 560 tons $\frac{\text{Beam}}{\text{Draft}} = 3{\cdot}2$			Destroyer, 390 tons $\frac{\text{Beam}}{\text{Draft}} = 3{\cdot}8$		
Speed, Knots	Effective Horsepower			Speed, Knots	Effective Horsepower			Speed, Knots	Effective H. P.		Speed, Knots	Effective H. P.	
	Experimental	Calculated by Formula	Calculated from Curves		Experimental	Calculated by Formula	Calculated from Curves		Experimental	Calculated from Curves		Experimental	Calculated from Curves
14	1,020	1,060	1,120	19	950	860	730	20	920	890	20	525	450
15	1 450	1,500	1,530	20	1,180	1,110	970	21	1,260	1,140	22	940	750
16	1.960	2,075	2,100	21	1 390	1,420	1,250	22	1,640	1,440	24	1,370	1,060
17	2,560	2,780	2,900	22	1,710	1,790	1,600	23	2,020	1,820	26	1,720	1,380
18	3,870	3,740	4,000	23	2,280	2,230	2,100	24	2,390	2,220	28	2,170	1,700
19	7.370	4,900	5.500	24	3,170	2,765	3,150	25	2,750	2,630	30	2,550	2,030

which $\frac{V^2}{L}$ is less than 1.2. As will be seen, it conforms to the law of comparison, and, compared with the formulæ which have already been considered, gives extremely good results for all classes and sizes of ships. It has been applied by the writer to over thirty different ships, and the general results of the application are as given below.

Most of the examples taken for comparison have been those of warships, and it was found in applying the formula that a slight modification gave better results. This modification consists in taking the length as the extreme length of immersed vessel in place of that on the waterline, and in calculating the block coefficient on the extreme length instead of that between perpendiculars, as usually taken. For merchant ships the two lengths are generally the same, but for warships the difference in the two is appreciable.

In only two cases of the many taken, were the calculated results for all speeds less than the experimental results. For the remainder, the following are the conclusions arrived at:

For vessels in which the block coefficient varies from 0.6 to 0.65, the calculated results are generally correct for a speed such that $\frac{V^2}{L}$ is about 0.85. Below this speed, the results are generally about 7½ percent larger, while above this speed the results are somewhat smaller than the experimental results.

For vessels in which the block coefficient varies from 0.5 to 0.55, the calculated results are generally correct for a speed given by $\frac{V^2}{L}$ equal to 1. Above this speed, the results are

*Transactions American Society of Naval Architects and Marine Engineers, Volume II, page 143.
†Not here published, for want of space.

slightly smaller, while below, they are generally about 10 per cent greater than the experimental results.

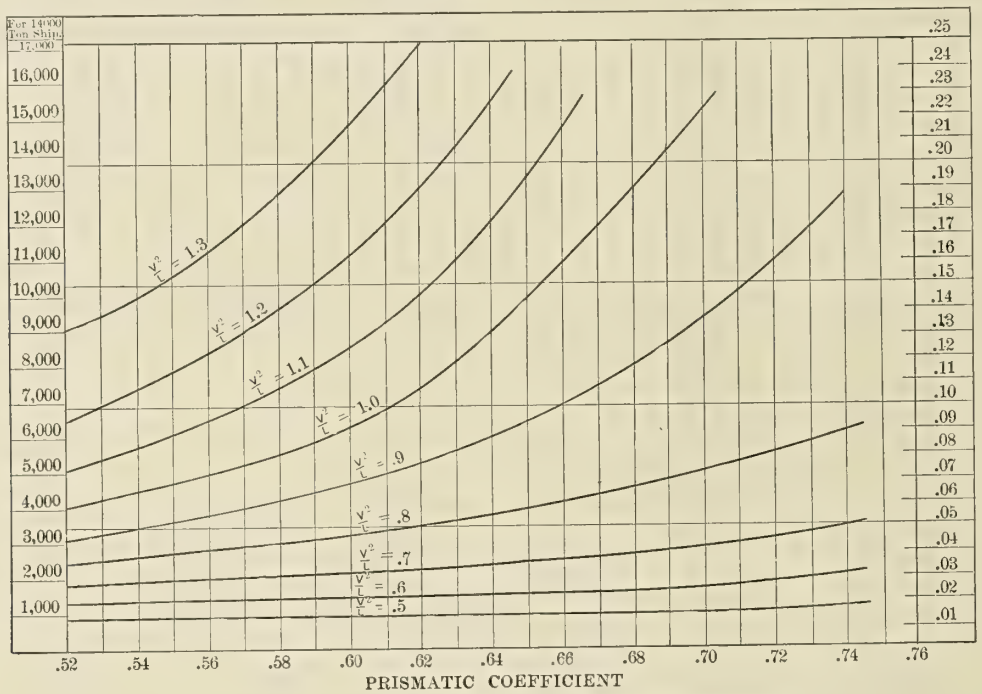
Considering that at the highest speeds the frictional resistance is nearly equal to the residuary resistance, while at low speeds the former is much greater than the latter, it will be seen that the formula gives extremely close results. In an article in a recent number of an engineering magazine,* Mr. Taylor has given a series of curves from which the residuary resistance in pounds per ton of displacement can be calculated for a ship of given displacement, length and speed. These curves are applicable to much higher speeds than the formula just considered, and can be applied to torpedo and other small fast vessels. Their method of application needs no explanation.

Applied to large ships, they give at the highest speeds better results than his formula, but at low speeds the latter gives better results. For the highest speeds of torpedo craft the curves give good results for vessels with a $\frac{\text{beam}}{\text{draft}}$ ratio of from 3.0 to 3.2. For vessels whose $\frac{\text{beam}}{\text{draft}}$ ratio is greater than this, the curves give too small a result. Table IV shows the results of the application of the formula and the curves to a few typical cases. In all cases the length has been taken as immersed length.

The writer has examined the resistance results of about seventy ships of various sizes and shapes, with the object of obtaining an approximate method of calculating the residuary resistance of a ship whose principal elements are known. Although no simple algebraic rule has been obtained, the residuary horsepower of ships up to speeds given by $\frac{V^2}{L} = 1.3$ can be approximately found by the use of the curves shown. In these curves the prismatic coefficients are taken as abscissæ, and the ordinates of the various curves measured on the scale to the right of the figure at the particular prismatic coefficient multiplied by the displacement of the ship raised to the 7/6 power, will give approximately the residuary horsepower required at the particular value of $\frac{V^2}{L}$ taken. The scale on the left of the figure is that for a displacement of 14,000 tons. In this case L is the extreme length of ship in feet under water, and V is the speed in knots. The prismatic coefficient is taken on the length between perpendiculars.

Above a ratio of $\frac{V^2}{L} = 1.3$ the residuary horsepower does not generally increase as the prismatic coefficient; in fact, in one or two cases, a substantial decrease is indicated. In a few ships of exceptionally good form, the curves give too great a result, but for ordinary forms of ships the curves give a good approximation to the results obtained by model experiments. In all cases the frictional resistance has been calculated by using the coefficients as determined by the late Mr. Froude.

The majority of cases examined are warships, but several merchant ships are included. It has been found in these cases that better results are obtained by increasing the prismatic coefficients by 0.02. This is due to the fact that in such vessels the length between perpendiculars is practically the immersed length of the ship, and not, as in the majority of warships, an appreciably smaller length. The curves apply to vessels in which the ratio $\frac{\text{beam}}{\text{draft}}$ varies from about 2.7 to 2.9. For greater ratios than the latter the curves give results which are smaller than they should be, while for smaller ratios than the former the results will be too great. An approximate correction for ratios of $\frac{\text{beam}}{\text{draft}}$ different from those mentioned can be made by use of Colonel Rota's curves.*



RESISTANCE CURVES USED TO DETERMINE RESIDUARY HORSEPOWER.

Other approximate formulæ have been published from time to time, but they are usually extremely long and complicated, involving much time in their application. The formulæ which have been considered in this paper are generally simple, but their application and comparison of results have taken considerable time. No doubt there are many other simple formulæ which have not been published, but which are at the same time extensively used in practice.

Marine Engineering, July, 1905.

*Transactions Institution of Naval Architects, 1905, Part II, page 334.

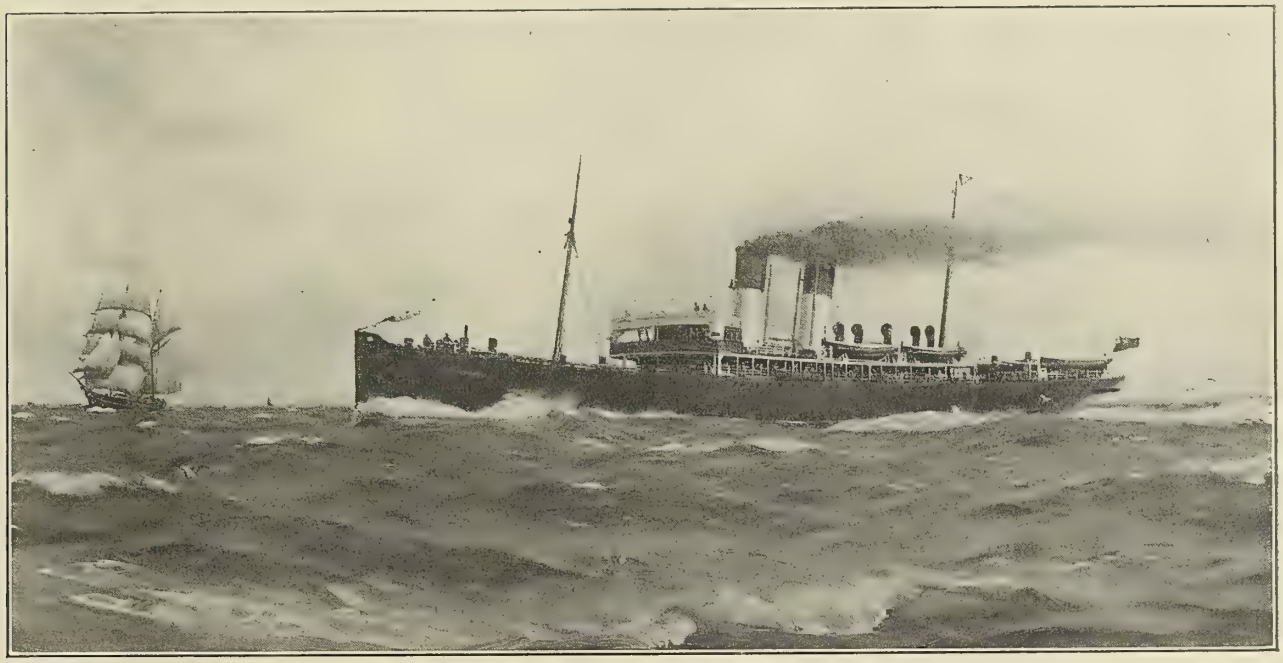
The *President Lincoln*, of the Hamburg-American Line, the first six-masted steamer since the famous *Great Eastern*, has completed her maiden trip to the port of New York.

The Triple Screw Turbine Steamer Marylebone.

Developments of the Grimsby to Hamburg service of the Great Central Railway Company are being pushed, and in the near future we may expect to see a large increase in the passenger traffic between the two ports. Two new steamers have just been placed on the service, the *Marylebone,* built on the Mersey by Messrs. Cammell, Laird & Company, Limited, and the *Immingham,* built by Messrs. Swan, Hnuter & Wigham Richardson, Limited, Wallsend-on-Tyne. Both vessels are excellent models. The *Marylebone* was the first turbine steamer to enter the port of Grimsby, and made the first voyage to Rotterdam for her owners on the 10th of January with a full complement of cargo and passengers on board.

Her principal dimensions are:

Length, over all	262 feet.
Breadth, molded	41 feet.
Depth, molded	21 feet 6 inches.
Tonnage, gross	2,000 tons.



THE TRIPLE SCREW TURBINE STEAMER MARYLEBONE, ENGAGED IN CHANNEL SERVICE.

She is designed to carry about 1,000 tons deadweight cargo; and 68 first class, 26 second class, and about 350 third class passengers.

The first class passengers are berthed in bridge house amidships, mostly in two-berth cabins of superior style, and finished in white enamel, ample lavatory accommodation being provided for both ladies and gentlemen.

One of the most prominent features of the ship is the splendid promenade deck, about 120 feet in length, with 10 feet of clear promenade space on each side. On this deck are placed two three-berth cabins and five two-berth cabins, three of which are situated at the forward end of the deck, and open into the handsome main entrance to the saloon. A broad companionway leads with wide stairways to the upper deck and into the dining saloon, and the surrounding paneling forms a very attractive entrance hall. All the woodwork in the dining saloon is of light polished oak, the upholstery of the settees and revolving chairs being of red morocco leather. Noticeable features of the saloon are its size, and the splendid light obtainable. There are no less than sixteen pivoted sidelights of large diameter, giving direct light to the saloon. The ceiling is white lined with gold, and, being dotted here and there with clusters of electric lights, it presents an exceedingly pretty appearance.

Leaving the saloon and proceeding aft along the upper deck, one finds the ladies' cabin tastefully upholstered in art blue velvet, and having a well appointed lavatory. There are eighteen two-berth cabins, two three-berth cabins and one four-berth cabin, all finished in white enamel and supplied with all the latest fittings. It is here that ample lavatory accommodation for gentlemen is arranged, including bath with hot and cold water.

From this point a companionway leads to the lofty smokeroom, which is a special feature of the ship. It is paneled in fumed oak and upholstered in red morocco leather, and provided with small tables and a serving bar for the convenience of passengers, and handsomely paneled doors leading to the after end of the promenade deck.

The second class passengers are berthed in the poop, which is well lighted and ventilated, and in accordance with the Board of Trade requirements; while the third class passengers have been arranged for in the 'tween deck, on the latest and most approved arrangement, with ample lavatory and hospital accommodation in poop and forecastle to meet the German emigration requirements.

The ship has been fitted with electric light on the double wire system. The electric light machinery, as well as the forced draft fans for the boilers are of Allen's (Bedford) make, the fan engines being of the inclosed self-lubricating type.

An auxiliary condenser is fitted for dealing with the exhaust from all the auxiliary engines. When running at full power this condenser is shut off and the exhaust from the auxiliary engines taken through the feed heater before it passes into the main condenser. A feed water filter is fitted for dealing with any impurities that may occur in the condensed steam from the auxiliary engines. This was supplied by the Liverpool Engineering & Condenser Company.

The feed pumps, oil circulating pumps, heater and evaporator are all of Weir's make. The circulating pumps are of the centrifugal type, and made by Matthew Paul of Dumbarton. The bilge, sanitary, water service and auxiliary boiler feed pumps have been supplied by Mumford of Colchester.

The Stone Lloyd system of hydraulically operated watertight bulkhead doors, which are under the control of the captain on the bridge, can be closed by him in eight seconds. Welin patent quadrant boat davits have been fitted, and telemotor steering gear.

The propelling machinery consists of a set of three compound steam turbines of the Parsons type, manufactured by the builders, and designed to develop not less than 6,500 horsepower at a

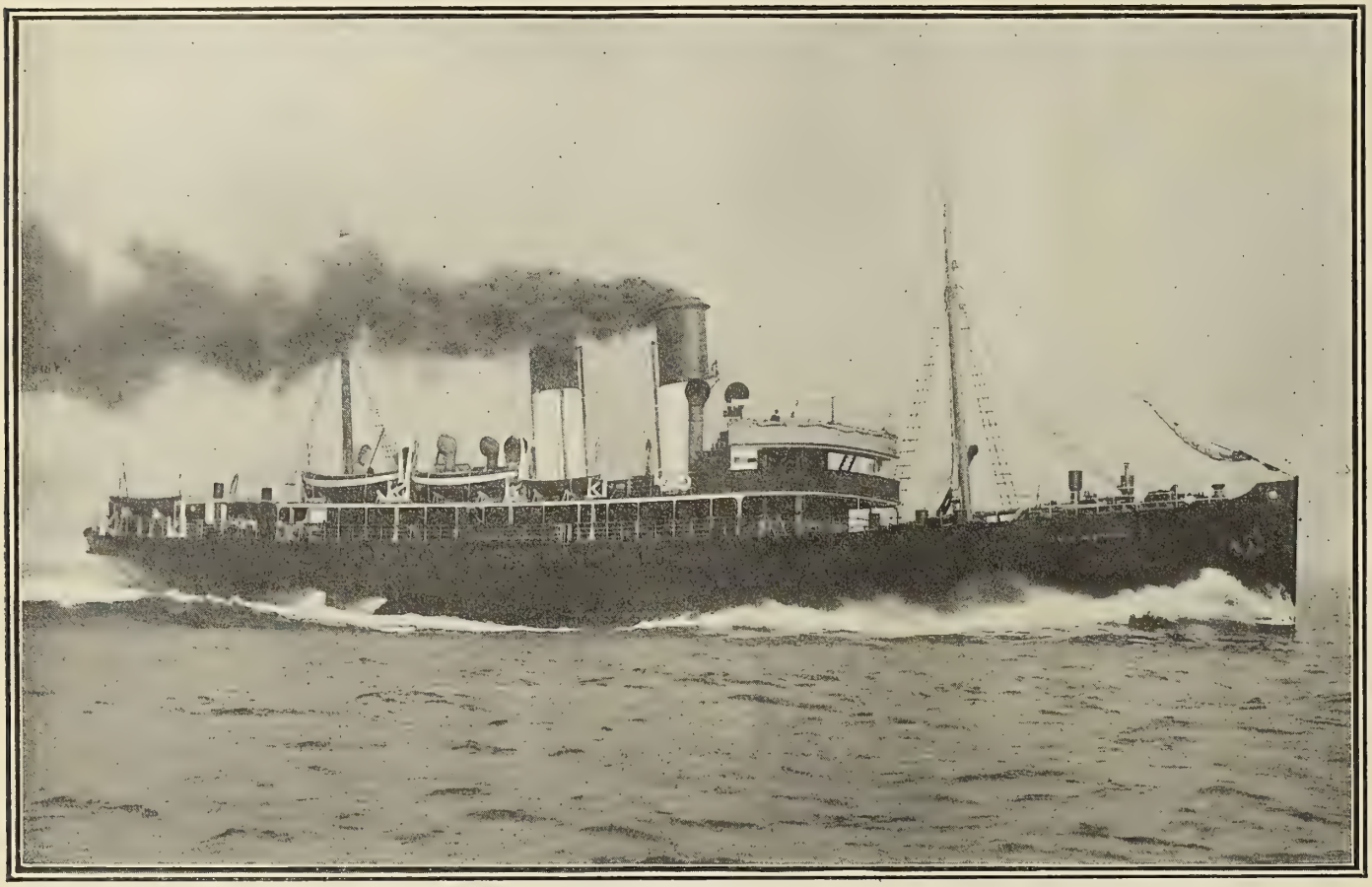
working pressure of 160 pounds per square inch. There are three lines of shafting, and the propellers are of bronze.

Several novel features are to be noticed in the machinery. The starting and maneuvering gear (Cockburn's patent flexible valve arrangement) is the first of its type fitted. This gear is operated by hand alone, and is extremely compact and simple. The maneuvering valves are automatic and safe in action, *i. e.*, one hand wheel controls the steam supply to both ahead and astern, it being impossible to make any mistake and open either valve until the other is tight shut. A Cockburn's flexible throttle valve is fitted in the main steam pipe, which in an emergency, by means of the governor gear, enables the steam to be instantly and absolutely shut off from the turbines.

Two condensers are fitted, one to each low-pressure turbine, the bodies being constructed of sheet steel and the ends of gun metal. Two of Parsons' vacuum augmentors are fitted, and the air pumps are of Weir's make.

The boilers, which have been made at the builder's works, are four in number, single ended, each with four corrugated furnaces, working at 160 pounds pressure. They are worked under forced draft on the Howden system. There are two boiler rooms, two boilers being placed in each compartment. In the forward boiler room is also one of Blake's patent vertical auxiliary boilers, which is large enough to supply steam for all the auxiliary machinery. Two of See's patent ash ejectors are fitted in each stokehold, and a duplex pump of Clarke Chapman's ejector type is fitted for supplying the necessary water under pressure.

The speed trials of this vessel were carried out under loaded conditions and consisted of a 24-hour trial at 17 knots, and a 6-hour full power trial at 18 knots. On the first trial a speed of 17¼ knots was obtained, and on the full speed trial the speed was 18.3 knots, the results thus realized being both in excess of the contract requirements. The machinery worked in the most satisfactory manner throughout. During the trials the power was ascertained by means of Chadburn's flashlight torsion meter. The torque of the shafting could be exactly read off at any moment, and by means of a diagram the shaft horsepower is obtained almost at a glance.



THE TURBINE STEAMER IMMINGHAM, SISTER TO THE MARYLEBONE, OF THE GREAT CENTRAL RAILWAY.

THE CAUSES AND PREVENTATION OF FIRE AT SEA.

BY PROFESSOR VIVIAN B. LEWES, F.I.C., F.C.S.

PREVENTION.

The question now arises as to the practically possible precautions that can be taken to minimize the occurrence of fire at sea. This portion of the subject may be briefly summarized as:

1. Constructional safeguards, consisting of subdividing the hold into smaller compartments than usual, and employing fire-proofed wood.

2. Safeguards of equipment, consisting of protecting all steam pipes, and taking all possible precautions with the electrical wiring of the ship.

3. Administrative safeguards, consisting of care in stowing cargo, proper inspection by patrols, and better fire equipment.

Excellent as these points are, many of them are not practicable under the conditions existing in the mercantile marine, and the subdivision of the cargo holds into smaller compartments, from the points of view of expense and efficient handling of the cargo, would certainly not recommend itself to the naval architect.

The use of flame-proof wood is undoubtedly a reform in ship-building which is urgently needed, and the fact that it has not yet been adopted is due, not to lethargy on the part of the naval architect, nor to any minimizing of the advantages that are to be obtained by the use of non-inflammable material; but to the simple fact that up to a short time ago the preparation of the wood had

*Read before the Institution of Naval Architects, March 22, 1907.

not reached that stage of perfection which would have justified the expense of adopting it. The idea of making timber fire-proof is no new departure, as more than three hundred years ago attempts were first made to render timber used for shipbuilding fire-proof, and from that time down to the present it has cropped up from time to time; perhaps the most notable attempts to solve the problem being those made by Sir Humphry Davy and by Faraday.

All these attempts failed, owing to the idea not being grasped that the protecting ingredients must be got into the structure of the wood itself, and must permeate it to the core, before it is possible to obtain any satisfactory result; and the fact that, although this could be easily done on the experimental scale in the laboratory, the great difficulties which stood in the way of doing it on the large scale led to failure in all the attempts. The cause of these failures is not far to seek. Impregnation of a most thorough character is a necessity, but every kind of wood has to be treated in a different way in order to meet the requirements of the varying densities, and as this depends not only upon the kind of wood, but also upon the age of the timber and the character of the soil on which it grew, not only had the process to be varied with different specimens of timber, but also for different samples of the same timber, when grown under different conditions, these being points which only now have come to be recognized.

A wide variety of substances have been suggested for fire-proofing, and the salts employed are now generally spoken of as "anti-pyrenes," but many of these have been found to be unsuitable, owing to their action either upon the wood or upon the materials which had to be used with it. One of the most popular substances in the early experiments was common salt, but it was soon found that the timber impregnated with this could not be commercially used, because of its hygroscopic properties. Other substances then employed to effect the fire-proofing were found to rot the wood, while some of them very rapidly corroded the nails and screws used with the impregnated timber. Other chemicals again, although they might do the required work for a short space of time, volatilized and left the timber as inflammable as it was before. Practical experience has narrowed the list of efficacious compounds to ammonium chloride, ammonium phosphate, ammonium sulphate, calcium chloride, magnesium chloride, zinc chloride, zinc sulphate, stannous chloride, alum, borax, boracic acid, and aluminum hydrate.

In making the wood non-flammable, the timber is run on small trolleys into a large cylinder in which, by means of a vacuum, all air and moisture are extracted from the cells of the wood, and the solution of the chemicals is then run in. The contents of the cylinder are placed under hydraulic pressure, carefully regulated according to the character of the wood, as a pressure which is needed by one kind of wood would crush and destroy the cells of another. Indeed, the success of the whole process depends upon minutiæ of this kind, and the placing on the market of improperly treated wood has created a prejudice against such processes, that has done much to retard its introduction. After impregnation, the completion of which is indicated by the gage glass on the cylinder showing that the right proportion of the liquid has been absorbed, the wood is removed, drained, and dried at a carefully regulated temperature. This again has a great influence on the quality of the finished wood, temperatures above 85° F. tending to render many kinds of wood brittle, while when dried at the right temperature the wood not only retains all its original qualities, with the exception of inflammability, but is thoroughly seasoned and ready for the joiner's shop.

Made in this way, non-flammable wood is a perfect building material, has no effect upon the workmen's tools, as was the case when the earlier anti-pyrenes were used, and will take paint, stains, varnish, and other decorative treatment as well as it did before fire-proofing. It now combines the advantages of excessively low conductivity with a great power of resisting fire, and entire freedom from spreading fire. This effect is caused by the chemicals used, consisting chiefly of ammonium phosphate and boracic acid, which, during treatment, crystallize in the cells of the wood, and can therefore never be removed. Under the influence of heat the ammonium phosphate decomposes to ammonia gas and phosphoric acid, the former driving all air out of the cells and replacing it by a non-flammable gas; while the phosphoric and boracic acids fuse, and coat the cell walls with a glaze which, while allowing the gases from the decomposing cellulose to escape, prevents the access of oxygen from the air to carry on further combustion.

Unfortunately for the rapid advancement of flame-proof wood, it was placed upon the market before it was perfected, and although the Admiralty was quite willing to take it up warmly, some slight trouble was found in the installation on the royal yacht, the wood not having been dried at the right temperature before use. As soon, however, as this was discovered and rectified, the results were found to be perfectly satisfactory, and a further modification introduced since that time eliminates what seems to be the last of the troubles standing in the way of its wide adoption. Nearly all the European powers are either experimenting with it or considering its adoption, and I am informed that all the woodwork on the new Italian ironclad *Roma* will be of this character. In the new ships of the British navy, wood has been used as little as possible, and comfort has to a great extent disappeared with it.

The use of fire-proof wood on all passenger steamers should be made compulsory, and it seems to me that at the present moment, when competition between the ocean lines is so keen, and every bid is made for the passenger traffic, the line which is wise enough to first see the importance of doing so, will secure for itself an advertisement that will pay the extra cost many times over.

I have my own views, however, on the way in which this should be carried out, and should never dream of advocating that a shipbuilder should be dependent upon any outside firm for the prepared wood. An apparatus for treating the wood should be installed at all large shipbuilding establishments, and the wood treated there, in order to prevent delays in delivery during the building of the ship. The cost of treatment nearly doubles the price of a cheap wood, but although this sounds almost prohibitive, it represents a very small percentage on the total cost of the ship; and it must be remembered that with a liner subsidized for use as a fast cruiser in time of war, there is timber enough in her top works to insure its being fired by a very few hits from the enemy's shell. By doing away with this danger by the use of properly treated wood, her value for such work should be enormously increased.

It seems to me that the whole onus of the introduction of a safeguard of this kind rests with the owner. No shipbuilder would take the initiative, as he looks upon his present burdens as quite sufficient for his own needs, and unless the use of flame-proof wood is specified, no advance will be made in this direction.

With the introduction of treated wood, the risks of overheating by steam pipes, and faults in electric installation, are minimized. Electricity has been responsible for many disastrous fires. Although one might consider it to be the safest form of illumination, as there is no inflammable liquid to spill, or gas to form explosive mixtures with air, yet defective cables and fittings have been a fruitful source of accidents. An excess of current may cause a leak in a weak part of a cable, and the short-circuiting causing heat, the bituminous envelope of the cable is decomposed, with the evolution of inflammable gases, which ignite by the spark and produce flame. A spark from the carbon of an arc lamp falling on inflammable material will start a conflagration, and many fires have been traced to the bulb of an incandescent electric light having been laid on light textile fabrics. In the last case the fabric soon begins to char, and in a very short time bursts into flames.

FIRE FIGHTING.

When a fire is once well started, the means that can be adopted for its extinction may be either by lowering the temperature of the burning mass below the point necessary for the continuance of the combustion, or else by cutting off all access of air, and so depriving the combustion of the oxygen necessary for its support. To the first method belongs the means usually adopted for extinguishing a fire, namely, that of pouring a large volume of water upon it. In doing so, several actions are brought into play. In the first place the temperature is reduced below the point of ignition, owing to the large amount of heat absorbed by the water; and secondly, as the water is heated up to its boiling point, an enormous volume of steam is generated, which drives the air away from the burning material. It may be stated roughly that about 5 pounds of water will require the combustion of one pound of well-dried wood to effect its conversion into steam, and as in a fire it is only the surface of the wood that is undergoing combustion, the effect of the 5 pounds of water will be felt over a considerable area. The steam generated occupies a volume about 1,700 times as great as that of the original water, and as steam does not support combustion in the ordinary sense, the evolution of this enormous quantity of gaseous matter serves to drive off the oxygen of the air from the neighborhood of the combustion, and so brings it to an end. The damage done to a mixed cargo by playing water into the hold makes it anything but a favorite method of extinction with the shipowner, and blowing steam into the hold when fire takes place is often adopted, in order to drive out air and so smother combustion.

I must confess to a strong prejudice against the use of either water or steam for coping with a fierce fire in a ship's hold, as under certain conditions they may give rise to troubles as bad as those they are intended to cure. Take, for example, a fire in a coal cargo. There is a mass of coal in the hold, with a pocket of incandescent coal near the bottom; the difficulty is in the first place to get at it, and the first impulse is to pump water in and let it find its way to the seat of the combustion. The water, however, cannot get freely to it in quantity, having to filter its way down through the interstices of the coal, meeting as it does so the hot products of combustion, and being evaporated off in cooling these down. The portion that does reach the seat of the combustion, on coming into contact with the red hot mass of carbon, is largely converted into water gas, a mixture of carbon monoxide and hydrogen, which requires only a small proportion of air to convert it into a highly explosive mixture. This, collecting under the decks, explodes, ripping up the deck and blowing off the hatches, thus letting in free access of air to carry on the combustion, which generally leads to the total loss of the ship.

It is even more difficult to get steam to the required spot, and steam, like water, is decomposed into water gas by incandescent carbon. The cooling action that steam has upon the burning mass is far less than would be the case with water, the chief value of which as an extinguishing agent is the large amount of heat rendered latent during its vaporization.

There are certain gases, however, which have a great power of stopping combustion by keeping away the oxygen of the air from the burning substance, and some of these have been proposed for the extinction of such fires. If we burn sulphur in oxygen, sulphur dioxide is generated, and this gas has a powerful effect in preventing and extinguishing fire, a small percentage of it being sufficient to extinguish flame. Its action, however, is purely extinctive, and in no way cooling; and with a cargo on fire the cooling down of the mass is every whit as important as the extinction of the active combustion. Another gas which acts in precisely the same way is carbon dioxide; but here again, if carbon dioxide be merely generated, and pumped into the area containing the burning matter, no absolute cooling is effected. Although the use of these gases was suggested over thirty years ago, it was this trouble which prevented their adoption.

With a proper arrangement of apparatus carbon dioxide could be made not only a most valuable extinctive agent, but also one of the most powerful cooling materials one could obtain. When carbon dioxide is compressed under a pressure of 36 atmospheres at a temperature of 0° C. (32° F.), it is condensed to the liquid state, and can be stored in steel vessels with screw valves. On opening the valve some of the liquid is ejected into the air, and being reduced to the ordinary pressure, is almost instantaneously converted into a large volume of gas. Conversion from the liquid to the gaseous state means the absorption of a large amount of heat, and so great is this that everything near the stream of new-born gas is cooled down, and some of the escaping liquid is frozen to a solid, having a temperature of —78° C. (—108.4° F.). The liquid carbon dioxide is now an everyday article of commerce, and is used to a large extent for aerating waters, driving torpedoes, and for freezing machines.

Certain suggestions as to the way in which the liquid gas might be utilized were never taken up, partly because there was a fear that, under the influence of heat, the cylinders might explode. If made in the same way as those used for the compressed hydrogen employed in military balloons, there need be no fear of a shattering explosion. The worst that could happen would be a ripping up of the cylinder along the weld of the seam, which would do no harm, but would be extremely efficacious in at once putting out the fire. Several firms have, however, adopted the idea for the protection of both coal cargoes and stores containing such goods as cotton, jute, or wool in bales, in which it would be extremely difficult to get at the fire by any other means. In most of these cases the cylinders are arranged externally to the store, and the gas turned on only when a fire is discovered.

It must be remembered that with the use of sulphur dioxide, instead of carbon dioxide, the same cooling effect would never be attained, and that the gas is so irrespirable that four parts in 10,000 render air incapable of being breathed; while with carbon dioxide, although 3 to 4 percent will extinguish flame, a man can breath for some time without danger an atmosphere containing over 10 percent.

Prevention is, after all, better than cure, and if a small extra cost in construction were faced, there never need be another cargo fire on steamers carrying cargo from one port to another; but the suggestion would not be applicable to tramp steamers breaking cargo at various ports of call. To insure this safety, all that is necessary is to abolish any attempt at ventilation for the cargo space, make the hold gas tight, and carry the cargo in an atmosphere of carbon dioxide, while any oxidizing materials, like nitrate, would be carried in a separate hold. In order to make safe steamers for carrying cargoes in large bulk, I should propose to make the holds larger rather than smaller, and to put in a double watertight bulkhead at each end of the cargo space, filling in the space in the end bulkheads either with water or heavy fuel oil, so as to render the hold gas tight. The hatches would be closed by iron covers, fitting into annular water seals, these covers being raised or lowered by the crane when required.

On loading a dangerous cargo—say, Indian coal during the hot season—when the cargo was all in and trimmed, a tarpaulin would be put over the hatch of the hold to be treated, and, one corner being raised, a hose would be lowered into the hold so as to reach the surface of the coal. Through this hose carbon dioxide, generated by the action of hydrochloric acid on chalk (calcium carbonate) or other cheap carbonate in a movable apparatus on the quay, would be passed, so as to drive out all air from the hold, and when a light held inside the hatch was extinguished, the hose and tarpaulin would be removed, and the cover lowered into position, thus making the hold gas tight. Under these conditions the most dangerous cargo could with safety be carried in an atmosphere of carbon dioxide, as there would be nothing to cause or support combustion, and should gas be generated from a coal cargo, so as to create pressure in the hold, it would blow the light water seal of the hatch cover,

and so relieve the pressure. In this way, not only coal, but crude oil, petrol, and any dangerous cargo could be carried without risk.

On reaching the port of discharge the hatch cover would be raised, and air from a blower forced down through the hose, escaping as low down in the hold as possible, and this, after an hour's blowing, would mingle with and displace the carbon dioxide and any gas that might have been formed, and when a safety lamp lowered into the hold burnt brightly, it would be safe for men to descend and commence the discharge, the air current being kept going all the time.

I am quite aware that the difficulty of making a bulkhead watertight is considerable, but I have too much respect for the engineering skill of the members of the institution to even suggest that it is impracticable, and if the big carrying lines had one or two vessels so fitted for the carriage of dangerous cargo, they would easily recoup the initial expense.

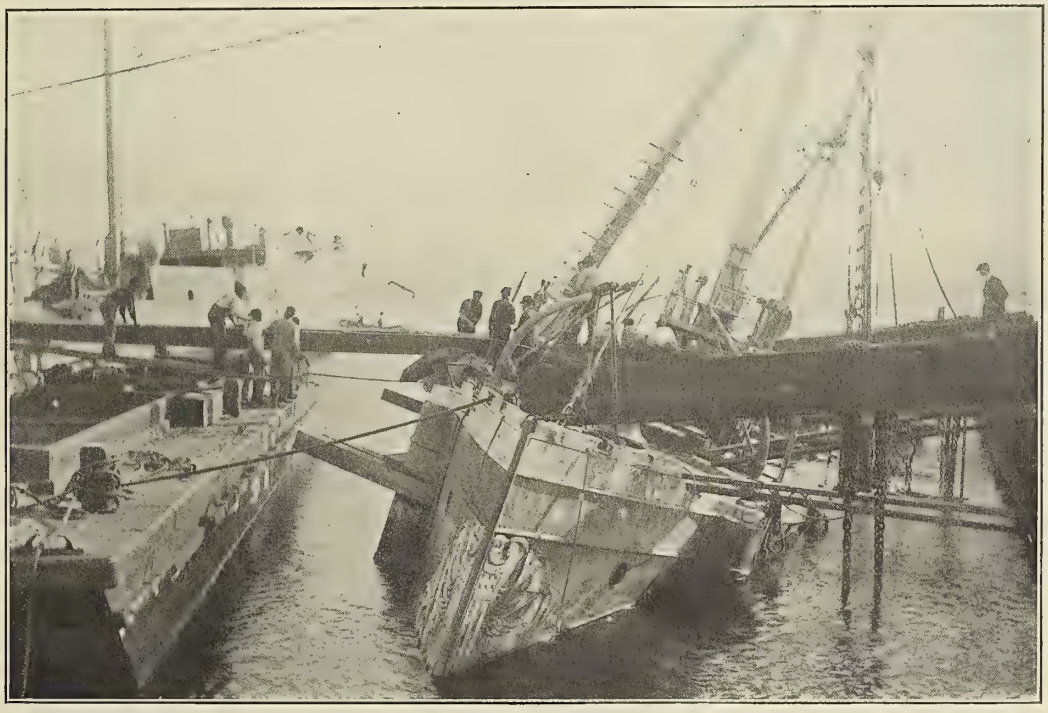
The amount of gas needed to fill up the space not occupied by cargo would be comparatively small, and although the supporters of existing systems would talk of the danger of leakage of the gas into the working and living parts of the ship, such danger is practically nil. Any such leakage would be brought about by straining of the bulkhead during heavy weather, and the liquid would have to leak out before any gas could escape, which would probably lead to the detection of the trouble; but, even if this were not so, there is no danger in the slow leakage of the gas, as it would practically escape by diffusion, and the increase in quantity in the living portions of the ship, even under the worst conditions of ventilation, would be extremely small, and as candle and lamp flames are extinguished before health is affected by mixtures of carbon dioxide with air, should a serious leakage occur, attention would probably be called to it by this fact.

In passenger vessels, chemical extincteurs, which throw a mixture of saline solution and carbon dioxide, would be of great value for extinguishing small fires occurring in bedding, draperies, and fittings, but they have not been adopted because, as ordinarily made, their use necessitates the carriage of mineral acids; it is, however, perfectly easy to make them without the use of objectionable acids, and so obviate this trouble, while the use of non-flammable wood for all fittings would give a degree of safety never yet attained.

Notes on Raising the Gunboat Machias.

During the hurricane that passed over Pensacola, Florida, September 26, 1906, the gunboat *Machias* was sunk at her moorings. At the time, she was moored in an old stone basin at the navy yard. This basin was at right angles to the course of the storm, but the water raising eight feet, brought the bilge of the ship on a level with the stone coping, and she pounded so severely that she sank, and large stones, weighing three or four tons apiece, were displaced by the impact.

When the water receded, it was found by soundings that the ship's hull was embedded 13 feet in the mud, there being a mean depth of water of 14 feet. The fo'c's'le deck was awash and the vessel listed about 22 degrees to port. Owing to the importance of other work, it was November before anything could be done towards raising the ship. At that time an attempt was made to right the vessel, while still submerged, in order that work could be carried on to better advantage. Timbers were laid across from the coping to the vessel, and chains were made fast, below water, to the side of the ship. Four sets were used, but all the chains broke when the jacks were brought to bear, without any appreciable movement of the ship. This plan was then abandoned, and it was determined to work on the vessel as she lay.



THE GUNBOAT MACHIAS, SHOWING TIMBERS IN PLACE FOR ATTEMPTED RIGHTING.

The *Machias* had been undergoing extensive repairs, prior to the storm, and the old locomotive boilers had been taken out to make way for two new Scotch boilers, so that the boiler space was clear when she went down. The main deck was thus off all the way across the ship, and for about forty feet fore and aft. A cofferdam was built all around this space, all holes that could be reached stopped up in the hull below the main deck, clear around the ship, and the main deck stopped up fore and aft of the cofferdam, thus taking advantage of the entire buoyancy under the main deck. An eight-inch and a twelve-inch pump were installed on the fo'c's'le deck as close to the water as possible, and the *Caucus*, an army dredge, with an 18-inch pump, brought alongside and piped down into the boiler space. Steam was taken to the small pumps from boilers located on a lighter at the bow, by means of flexible hose. When everything was ready, pumping was commenced, the water was rapidly lowered, the ship came up by the head for about 10 feet,

DECK VIEW, SHOWING PIPE LED FROM DREDGE CAUCUS ON FIRST ATTEMPT AT RAISING.

and listed to port to about 30 degrees from the vertical; the limit of lift of the 18-inch pump was then reached and the suction lost, there being no foot valve. The 12-inch and 8-inch pumps were inadequate to overcome the leaks, and the ship sank back.

From the first attempt it was plain that the only pump that could be depended upon was the 18-inch, so a foot valve was made for it of plate steel, of the double flap type, a hole cut in the side of the ship for the pipe, and two elbows taken out, making a gain of 8 feet on the water head. Chains were passed over the bow and fastened to a lighter loaded down with stone, to keep the bow down, and an "A" frame of 100 tons capacity was built and fastened by a chain through the after gun ports to the stern, with the object of breaking the after part of the ship out of the mud. Falls were then fastened to the masts, and carried over to the other side of the basin, and three Spanish windlasses rigged up on the stone coping, with chains fastened to the side of the ship. When pumping began, gangs

COFFERDAM AND ARRANGEMENT FOR SUPPLYING STEAM TO THE PUMPS MOUNTED ON FORECASTLE.

of men took a strain on the falls and the windlasses, to prevent as much as possible the careening of the ship. The vessel came up on a comparatively even keel, but with a list of about 40 degrees to port. Men then went down inside, and by cutting out rivets allowed the water to drain out of the compartments on the port side; the ship then righted. She was then floated out to the floating dry-dock for repairs. The hull on the port side was found mashed in for about 70 feet to about ten inches in depth, where it had pounded on the stone coping of the side of the basin. Other damages were sustained from collision with the *Isla de Luzon,* a gunboat undergoing repairs at the yard, which floated against her before she went down.

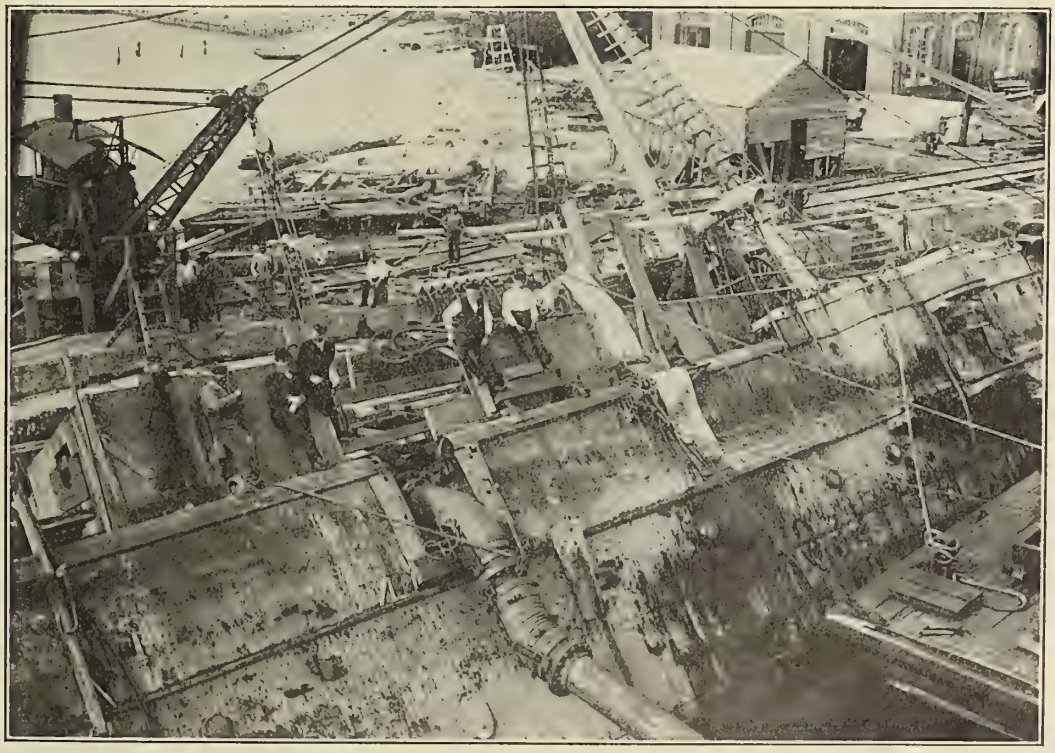
THIS VIEW OF THE OPERATIONS SHOWS THE METHOD OF ATTACHING THE A-FRAME TO THE STERN.

The *Machias* is an unarmored steel gunboat, built by the Bath Iron Works. Length 204 feet; breadth 32 feet 2 inches; mean draft 12 feet; displacement 1,318 tons. Twin screw vertical triple expansion engines gave an original horsepower of 2,046, and speed of 15.46 knots. The battery includes eight 4-inch rapid fire guns.

The ship was launched in December, 1891, and was first commissioned in July, 1893.

The Wreck of the Fearless.

A collision between the steamship *Fearless,* of the Houston Line, and the steamship *Patrician,* which occurred in February of 1906, was followed by the beaching of the *Fearless* at Egremont, near Liverpool. The rising of the tide broke the ship's back, and the vessel was towed in two parts to Tranmere for breaking up.

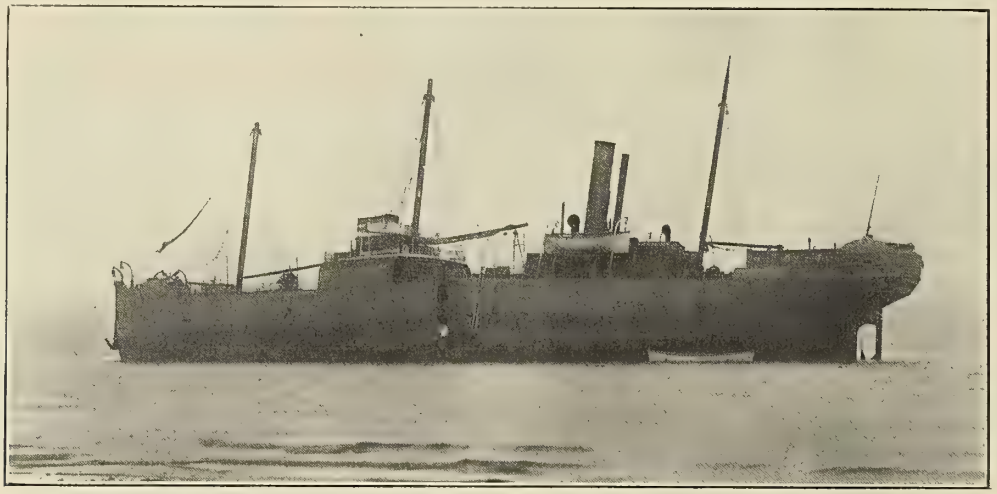


VIEW SHOWING DETAILS OF FLOATING AND RIGHTING OF THE SHIP.

The *Fearless,* which was built by W. H. Potter & Son, of Liverpool, was launched in August, 1878, and measured 896 tons net and 1,422 gross. She had a length of 264 feet 8 inches, a

beam of 32 feet 1 inch and a depth of 21 feet 8 inches, being constructed of iron with six bulkheads, and rigged as a schooner. She was propelled by a single screw, operated by a triple expansion engine with cylinders measuring 20, 32 and 52 inches in diameter and 36 inches stroke. She was engaged in trade between Hamburg and Liverpool.

The *Patrician*, which was built in 1901 by C. S. Swan & Hunter, Ltd., at Newcastle, is a steel screw steamer measuring 4,859 tons net and 7,474 gross. She has a length of 470 feet, a beam of 56 feet 2 inches and a depth of 31 feet 8 inches, and is fitted with nine bulkheads. She is propelled by a triple expansion engine, having cylinders 27½, 45½ and 75 inches in diameter, with a stroke of 60 inches.



THE STEAMSHIP FEARLESS, BEACHED AND BROKEN IN TWO ON THE EGREMONT SHORE.
(Photograph by Priestley & Son.)

The Towboat Norwich.

BY ROBERT R. UPDEGRAFF.

What is supposed to be the oldest steamboat in the world lies in Rondout creek. This is the towboat *Norwich* of the Cornell Towing Company's fleet of Rondout, N. Y. The cause of her predicament was a fire which broke out, supposedly in the boiler room, on December 16, 1906. On account of the danger of the fire spreading to the other boats lying near, the *Norwich* was towed out into the creek, where she was sunk to the guards by the large quantity of water poured into her hold. The exact damage done by the fire is unknown. From the outside little damage is apparent, although the pilot house is gutted, and the high framework inclosing the cross head engine was badly burned.

There are few boats afloat better fitted for ice breaking than was the *Norwich*. On account of her peculiar bow construction she was able to run up on the ice, and then her weight bore upon it until it broke in pieces, and lowered her into the water again. This operation would be repeated, each time with a gain of a few feet. Many an ice gorge has been broken up in this way by this craft, thereby saving thousands of dollars worth of property along the river front.

The *Norwich* was built for the New York and Norwich Steamboat Company, in 1836, by Lawrence & Sneeden. She was first used as a passenger boat on Long Island sound. Later she was used to transport passengers and freight from Piermont to New York. In the early "fifties" she came to Rondout, and was used, in connection with the *Emerson*, as a passenger and freight boat between Rondout and New York. As more modern boats were built and larger boats were required, the *Norwich* was retired from passenger service, to be utilized later as a towboat.

THE TOWBOAT NORWICH, PARTIALLY SUBMERGED AND FROZEN IN, NEAR RONDOUT.

The boat was 160 feet long, 25 feet wide, and her hold was 8 feet deep. She had a gross tonnage of 225. Her boiler was 26 by 10 feet. The engine had one cylinder 41 inches in diameter, with a 10-foot stroke. Her cross head engine was the last of that type on the Hudson River.

THE BOW OF THE DAKOTA UNDER WATER OFF SHIRAHAMA, MARCH 11, 1907.

Loss of the Steamship Dakota.

The latest advices show that the *Dakota* is a total loss. In passing over the reef just outside the harbor of Yokohama, Japan, the bottom and bilges were torn open for more than 200 feet. On March 23, the ship was broken in two parts during a heavy southeast gale. She separated between the engine room and the fire room. The forward end disappeared under the water, the after end rolled over on beam ends, and has since been entirely broken up. This ship, and her sister *Minnesota*, were the largest vessels ever built in the United States, and have been given adequate description in these columns. Our photographs are from T. M. Laffin, 42 Exchange Market, Yokohama.

SHOWING THE ROCKY CHARACTER OF THE COAST AT SHIRAHAMA.

A Disastrous Boiler Explosion.

On February 13, 1907, the donkey boiler on the steamship *Valdivia*, of the Hamburg-American Steamship Company's Atlas Line, exploded, killing seven of the crew, injuring four others, and wrecking the smokestack and superstructure of the vessel amidships. At the time of the explosion the *Valdivia* was about a hundred miles south of Hatteras, bound for New York from Kingston. According to the statement of the chief engineer, the boiler, which at its last inspection had been allowed a working pressure of 90 pounds, was in good condition, and fifteen minutes before the explosion occurred was under a pressure of only 35 pounds per square inch, as indicated by the steam gage.

The boiler was a Cochran vertical cross tubular boiler, 11 feet 4 inches in height, 63 inches diameter, built of steel by Clarke, Chapman, Parsons & Company, of Gateshead-on-Tyne, in the year 1886. It was located on the main deck of the vessel, forward of the smokestack of the main boilers. The dimensions in the drawing are given in millimeters.

The shell of the boiler was made up of three courses, the middle being the outside, as it lapped the upper and lower courses. The middle plate ruptured all the way across at a point about 2 inches from the lap of the longitudinal seam; then it tore around to the front tube plate about five-eighths of the circumference, and just above the seam of rivets joining it to the bottom shell plate. The top shell plate tore off entirely around the boiler, directly above the seam of rivets joining it to the middle shell plate, in a more ragged manner than the other plate; thus the upper shell plate and head were free from

THE STERN OF THE SHIP WAS SO FAR OUT OF WATER THAT THE PROPELLERS WERE CLEAR.

the lower part of the boiler and were blown overboard, taking the safety valves, main and auxiliary stop valves, water gages, steam gage and gage cocks along. The heavy lines show the manner in which the plates were ruptured.

The plate forming the back of the combustion chamber collapsed, and laid against the back tube plate, about 13 inches further away from the shell than when in its original position. This plate was rolled to a radius of about 27 inches, and was stayed with 1⅛-inch diameter screw stays to the shell plates; stays pitched about 10½ by 14 inches, except that in the second row from the top, one stay was left out in the middle, as it came opposite a manhole in the shell. Some of the stays broke off at the back connection plate, but most of them pulled through the shell plate, into which they had been screwed and the ends riveted over; on the other end, the stays were screwed into the plate, and, in addition, had a nut on the end. The holes in the back connection plate around the stays were stretched to such an extent that the stays could be moved around by hand and, in several cases, the nut was all that prevented pulling them out of the plate.

The support for the above plate would seem to be insufficient, as the following will show:

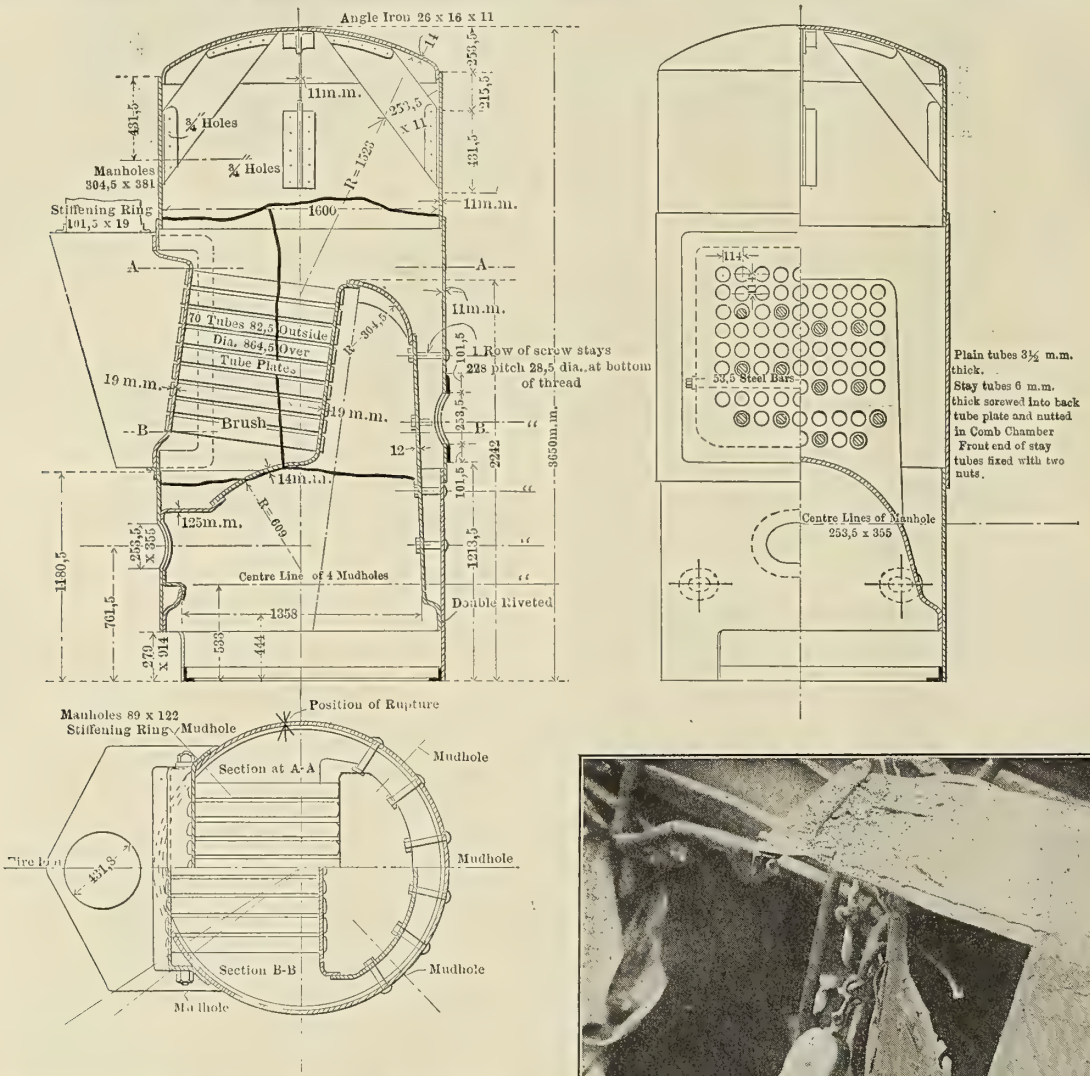
$$\frac{0.994 \times 6000}{10\frac{1}{2} \times 14} = 40 \text{ pounds per square inch, safe load;}$$

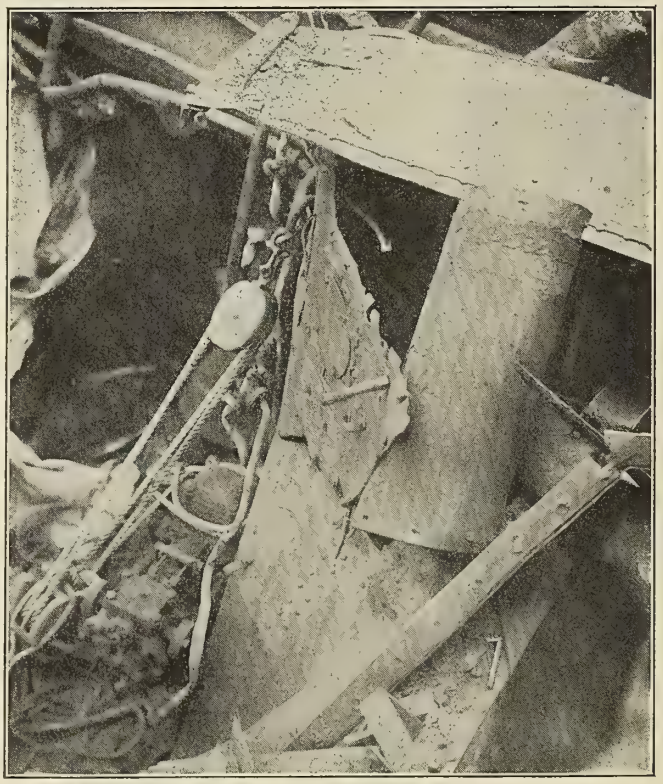
or, taking that part where the stay is left out:

$$\frac{0.994 \times 6000}{147 + 36.75} = 32 \text{ pounds per square inch, safe load.}$$

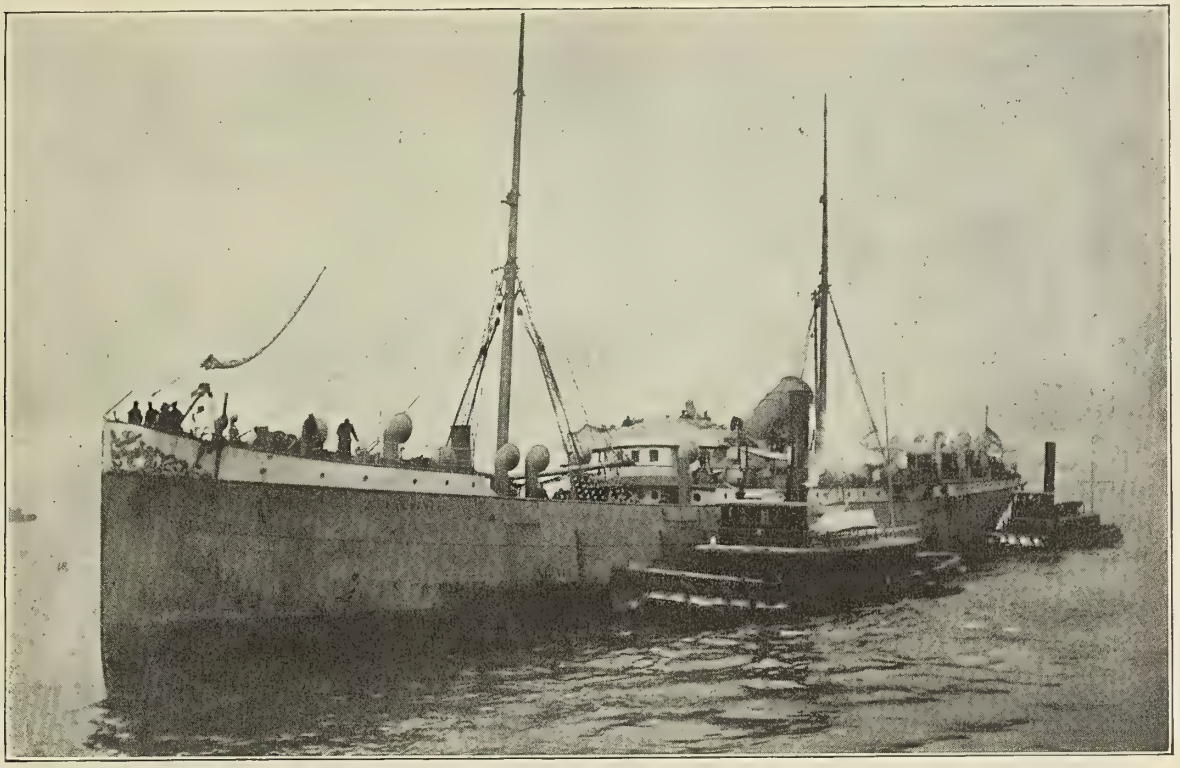
Or, assuming that the tensile strength of staybolt steel was 48,000, then $32 \times 8 = 256$ pounds, the ultimate strength of the stays. Of course, the circular form of the plate would assist in maintaining the plate in its position.

The plate forming the middle course was considerably reduced by pitting along the line of rupture across the plate, the pitting extending for a distance of from 10 to 20 inches in width. The following measurements were taken along the ruptured edge of the plate about 1 inch from the edge: 0.414 inch in thickness at the upper lap, which must have been the original thickness, as the plate did not show any signs of wasting away on the outside;


Angle Iron 26 x 16 x 11
11m.m.
¾ Holes
Manholes 304,5 x 381
Stiffening Ring 101,5 x 19
1600
70 Tubes 82,5 Outside Dia. 864,5 Over Tube Plates
19 m.m.
Brush
1 Row of screw stays 228 pitch 28,5 dia. at bottom of thread
Plain tubes 3½ m.m. thick.
Stay tubes 6 m.m. thick screwed into back tube plate and nutted in Comb Chamber
Front end of stay tubes fixed with two nuts.
53,5 Steel Bars
Centre Lines of Manhole 253,5 x 355
125m.m.
Centre Line of 4 Mudholes
Double Riveted
1358
Manholes 89 x 122
Stiffening Ring
Mudhole
Position of Rupture
Section at A-A
Section B-B



THE EXPLODED BOILER ON THE VALDIVIA.



THE HAMBURG AMERICAN STEAMER VALDIVIA AFTER THE EXPLOSION OF THE DONKEY BOILER.

0.363 inch in thickness, taken 7 inches down from upper edge.
0.328 inch in thickness, taken 14 inches down from upper edge.
0.260 inch in thickness, taken 21 inches down from upper edge.
0.225 inch in thickness, taken 28 inches down from upper edge.
0.288 inch in thickness, taken 45 inches down from upper edge.
0.382 inch in thickness, taken at bottom of plate.

No doubt the plate was reduced somewhat where the measurements were taken by being drawn out.

Assuming the tensile strength of plate to be 60,000 pounds, then

$$\frac{60{,}000 \times 0.225}{31.5} = 427 \text{ pounds, bursting pressure;}$$

and $427 \div 6 = 71$ pounds safe load. An average of the seven measurements equals 0.323 inch.

$$\frac{60{,}000 \times 0.323}{31.5} = 615 \text{ pounds, bursting pressure;}$$

and $615 \div 6 = 102$ pounds, safe load.

The last inspection by the German government inspectors was made on October 15, 1904, when the donkey boiler was tested to 11⅓ atmospheres (161 pounds), found to be tight and in good condition, and allowed 6⅔ atmospheres (93 pounds) steam pressure, as shown by abstract filed at the office of local inspectors, port of New York.

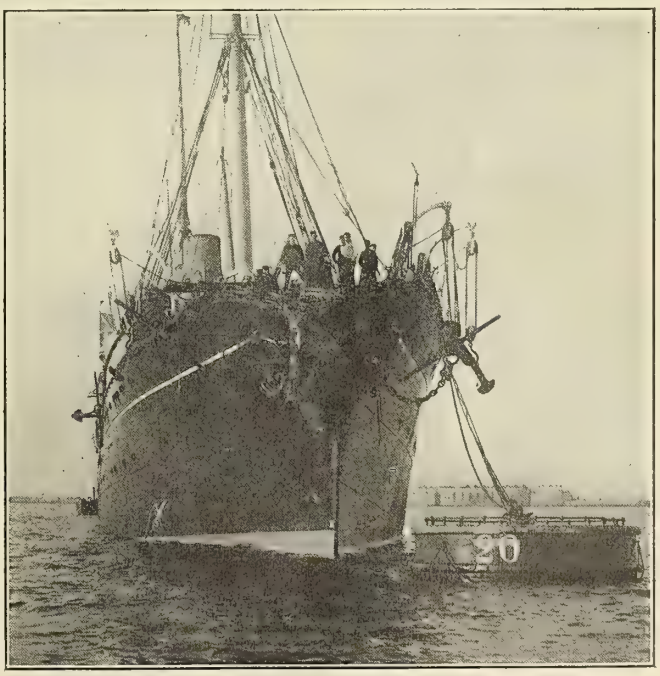
J. L. Crone, of New York, assistant inspector of boilers of the United States Steamboat Inspection Service, makes the following statement in his report regarding the cause of the explosion: "After making a thorough examination of the wrecked boiler, and from the general destruction of bulkheads, decks, above and below the boiler and other parts of the vessel, I am of the opinion that the boiler had a pressure on it greater by several times than the 35 pounds reported; also, that the back connection plate collapsed first, and this shock, together with the ordinary strain exerted on it, due to the pressure, ruptured the shell."

The ship was towed to the Erie Basin for repairs, after which she has resumed her service on the line between New York and West Indian ports. She is 308 feet long, and measures 2,176 tons gross.

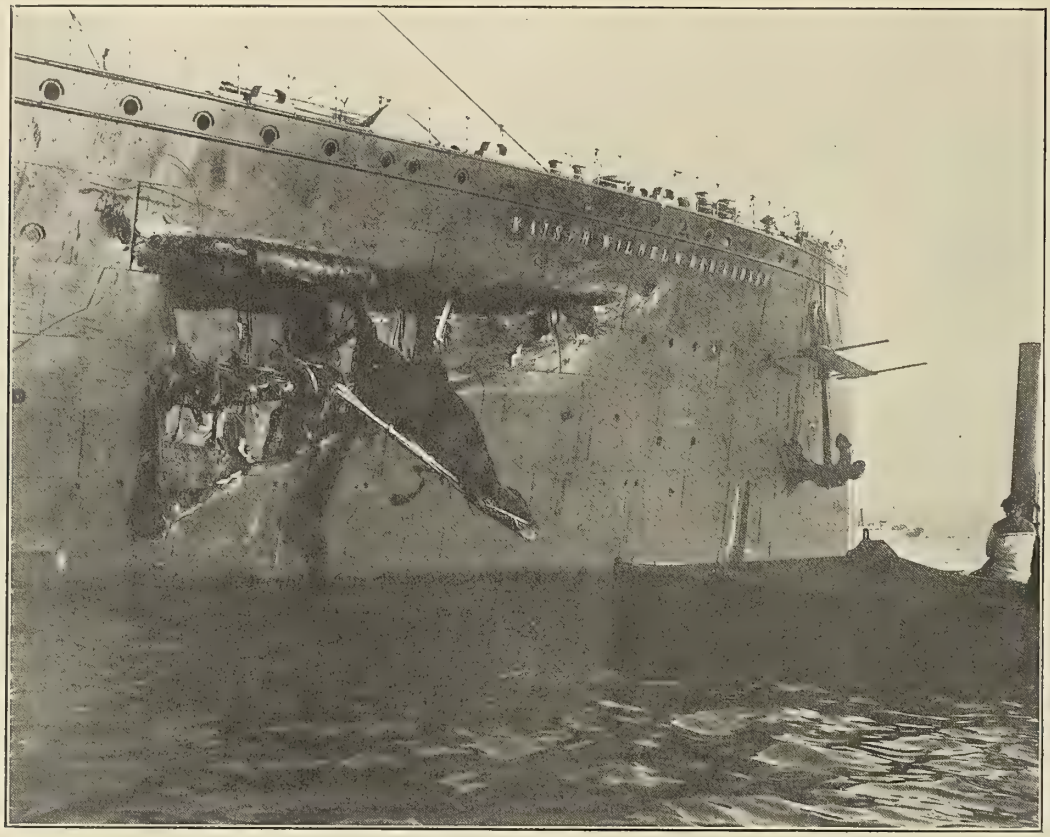
The Collision Between Kaiser Wilhelm der Grosse and Orinoco.

BY J. PELTIER.

On November 21 last, the steamship *Orinoco* was entering Cherbourg harbor, in the course of a voyage from Southampton to the West Indies, with passengers and general cargo; the *Kaiser Wilhelm der Grosse* was leaving the port, in the course of a voyage from Bremerhaven to New York, at 7 o'clock at night. The weather was overcast but clear, and it is said that the *Orinoco,* when entering the port, threw her helm hard aport to keep her to her own starboard side—the west passage into Cherbourg; but the German liner neglected to keep to her



THE ORINOCO AFTER THE COLLISION.



THE STARBOARD BOW OF THE KAISER WILHELM DER GROSSE WAS SERIOUSLY DAMAGED.

proper side of the channel, and attempted at great speed to cross ahead of the *Orinoco*. In spite of the fact that the latter's engines were reversed full speed, a collision was inevitable, and she ran into the German liner's side. A hole was torn forward on the starboard side about 3 feet above the waterline, 70 feet in length and 26 feet in breadth. Five persons were killed and several others injured on the *Kaiser Wilhelm der Grosse* and three were drowned from the *Orinoco*, which had her fore part crushed in.

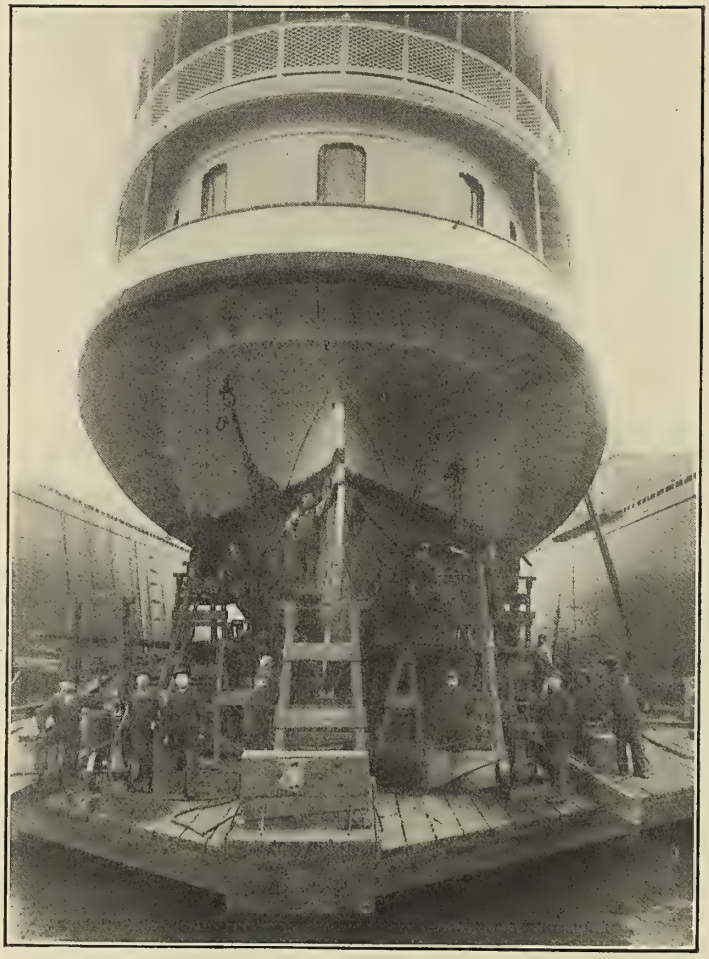
The *Kaiser*, having not less than sixteen watertight compartments, is, even in a collision of the most serious character, practically unsinkable. The damages of the *Orinoco* were not sufficient to place her in danger, and the following morning she returned, without assistance, to Southampton. After preliminary repairs, the *Kaiser* went to Gestemunde, but she could not enter the dry-dock until she had discharged about 2,000 tons of coal.

The accompanying photographs show the damages sustained by both steamers.

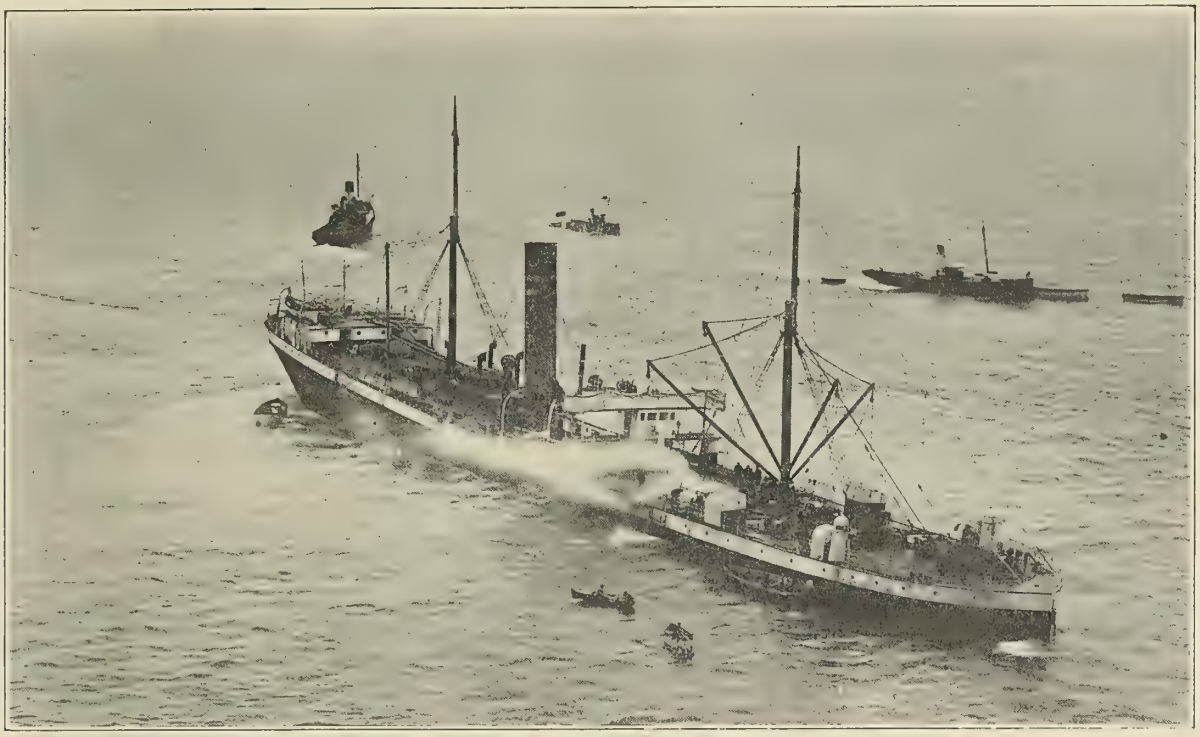
Repairs on the Sandy Hook.

The fast steamer *Sandy Hook*, belonging to the Central Railroad of New Jersey, has lately been in dry-dock at the yard of James Shewan & Son, foot of East Houston street, New York, for repairs. The photograph shows that the two after struts for the twin screws were being bored out simultaneously, the boring bars and gears being fitted, each to be operated by belt from a small engine, two of which were located on the floor of the dock. While this was being done, the rudder was also lifted for renewal of pintle bushing. The differential gears and chains by which the rudder was hoisted are shown in the photograph. It will be noted that each propeller shaft on this steamer has two outboard struts, due to the fine lines of the hull aft. The propellers, which are solid castings, are seen on the floor of the dock. The dry-dock on which the *Sandy Hook* was lifted out of the water is of the floating type, with a capacity of 3,500 tons.

The steamer was built in 1889 by Harlan & Hollingsworth.



THE SANDY HOOK ON FLOATING DOCK FOR REPAIRS.

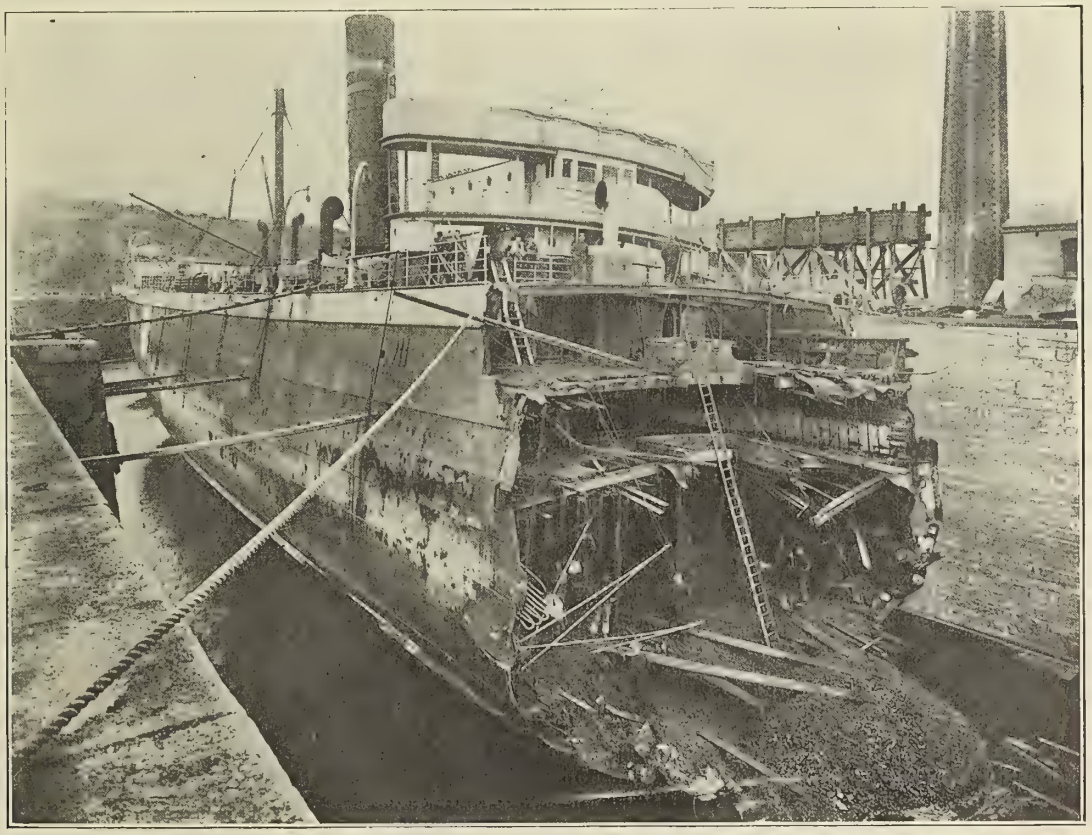


THE STEAMER HIGHLAND FLING, WRECKED ON THE LIZARD, NEAR CADGWITH.

Wilmington, Del., and measures 260 feet 5 inches by 37 feet 1 inch by 14 feet 3 inches deep. The net and gross tonnages are respectively 988 and 1,560. The vessel is built of iron and has six watertight bulkheads. She is propelled by two triple expansion engines with cylinders 22, 36 and 55 inches in diameter and a stroke of 28 inches. Steam is furnished by four return tubular boilers working at 160 pounds pressure.

Salvage of the Highland Fling.

This vessel was a steel screw steamer of 2,481 tons net, and 3,822 tons gross. She was launched by Hawthorn, Leslie & Company, Ltd., Newcastle-on-Tyne, in February, 1890. Her dimensions were: length, 350 feet 5 inches; beam, 47 feet 7 inches; depth, 24 feet 1 inch. There were seven watertight compartments. Her engines are three cylinder triple expansion, with cylinders 27, 44

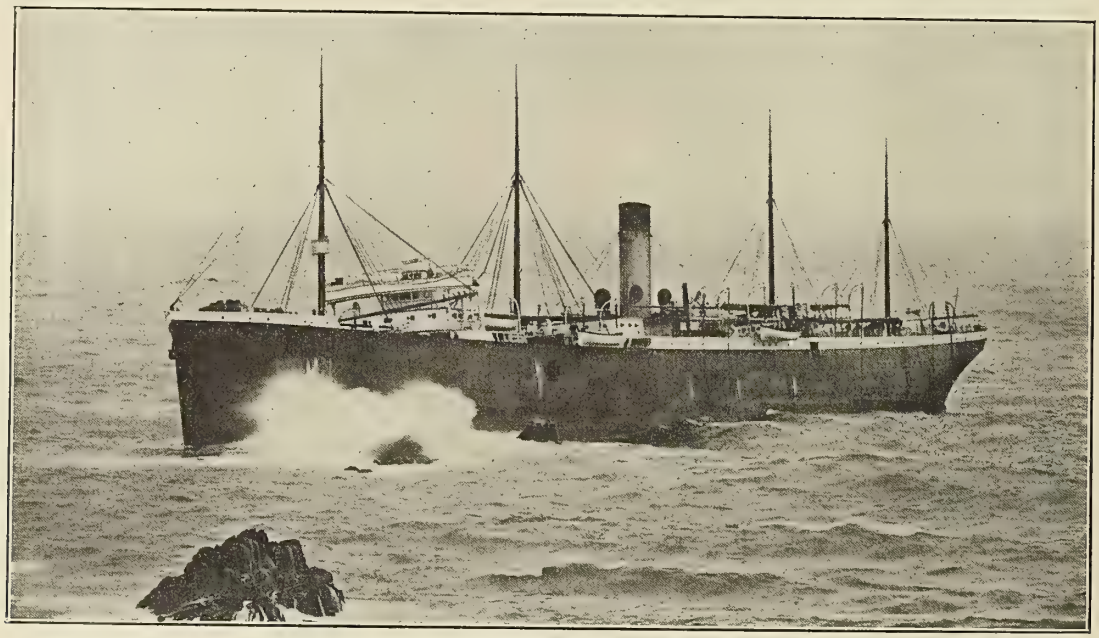


THE SALVED AFTER PORTION OF THE HIGHLAND FLING WAS PUT INTO DRY-DOCK AT FALMOUTH.

and 71 inches in diameter and a stroke of 48 inches. The working steam pressure was 160 pounds per square inch. She is owned by H. & W. Nelson, Limited, of the Nelson Liverpool Line.

She was sailing from London to Rosario via Cardiff when, on January 7, 1907, she struck on the rocks near Cadgwith, The Lizard, in foggy weather. The fore end of the vessel immediately began to fill with water. The passengers were rescued by lifeboats. Later four tugs were employed to refloat her, but even with the assistance of her own main engines, she could not be moved. She was firmly fixed on the rocks, forward of the bridge, heading north. Later pumps were unable to cope with the inrush of water. Eleven hundred tons of cement were jettisoned, and all efforts to refloat for the next few days were of no avail; twelve-inch pumps had no effect.

On January 12 there was a heavy ground swell; all tank tops were gone; 'tween decks were burst up; all pillars broken, and water was ebbing and flowing in the vessel with the tide. The fore end suffered severely, but all bulkheads and compartments aft were dry. For the next few days all efforts to refloat were unsuccessful, so the owners decided to cut the vessel in two forward of the bridge. This was done with dynamite on January 22, and the fore end of the vessel broke up and disappeared. The after end was safely towed into Falmouth harbor, and the valuable engines saved. The present estimated value of the vessel is about £27,500 ($135,000).



THE SUEVIC ASHORE. THE CROSS ON THE HULL, BETWEEN BRIDGE AND FUNNEL, SHOWS WHERE SHE WAS CUT IN TWO.

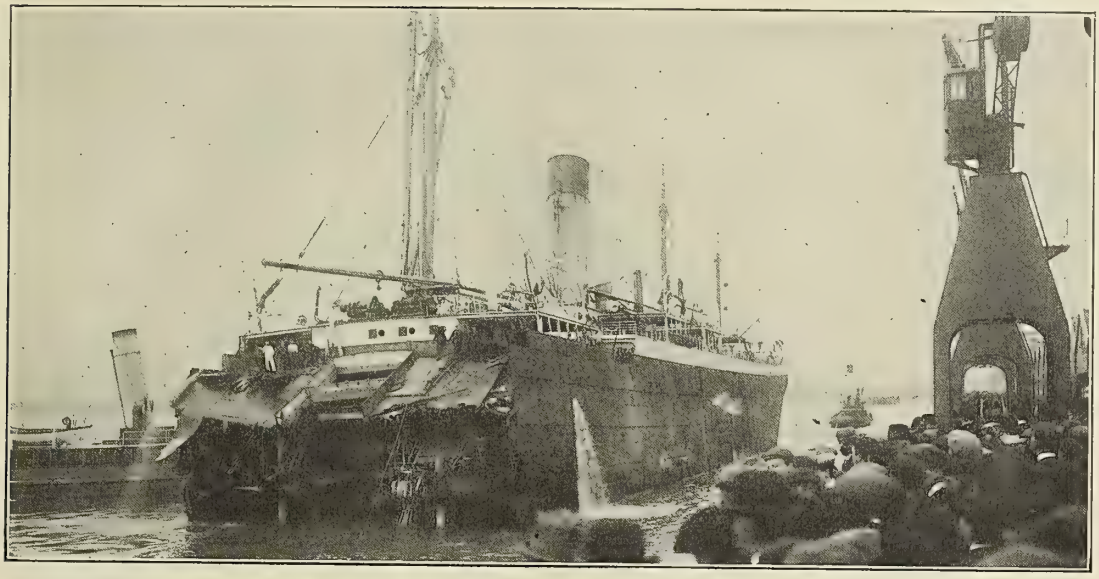
Salving of the Steamship Suevic.

The stranding of the White Star liner *Suevic,* a fine steel twin-screw four-masted steamer, built in 1900 by Harland and Wolff, Belfast, occurred March 17 last, off the Lizard. Her length was 550 feet, breadth 63 feet, depth of hold 39 feet 9 inches, and gross ant net tonnages 12,500 and 8,108. She was credited with a speed of 13 knots, and was one of the largest steamers fitted with refrigerating machinery for the conveyance of foreign produce. She had quadruple expansion engines with cylinders 22, 31½, 46 and 67 inches in diameter, with a stroke of 51 inches.

At first it was thought that it would be impossible to save the ship, but after three weeks' hard work the salvors, by means of a series of clever blasting operations, cut the vessel in two, and have saved the major portion. This part, about 400 feet in length, containing the engines and boilers, was towed free of the rocks, and after a perilous voyage in rather dirty weather, was safely docked at Southampton. The operations connected with the salving of the *Suevic* were of a most interesting nature, and were conducted by the Liverpool Salvage Association. A couple of hundred men were employed on the wreck, with a number of powerful tugs to lend assistance. The process was necessarily slow. Owing to the ship's being loaded, all the work had to be done from the outside. One of the divers stated that the *Suevic* was resting on the remains of two other wrecks, the winches of which could be seen in perfect order. The sea was occasionally so rough as to retard work, and fog likewise descended to add to the perils of the situation.

When darkness fell on the last night of the operations, every few seconds could be heard the deep, melancholy note of the *Suevic's* syren, giving warning that another charge of dynamite was about to be exploded. Then there was a sharp flash, followed by the loud report. When morning came the explosions were no longer below the surface of the water, but on the deck of the ship. Then it was found that only the main deck, which is composed of steel, remained to be separated. Precautions had, meanwhile been taken against the ship's being forced on to the rocks by heavy seas, when released. Two anchors had been run out at the stern, and the cables were hauled taut. The sea continued rough, and the watchful tugs rode at anchor at a respectful distance from the wreck. The heavy swell from the Atlantic increased, and it was obvious that the turbulence of the water would assist in the parting of the vessel. This proved to be the case, for with loud sounds of grinding and snapping the after part of the *Suevic* was, as the salvors expressed it, "alive," and commenced to rise and fall buoyantly in the swell, showing that the disunion of the vessel had at last been achieved.

Tugs were brought into position, hawsers were attached and the rescued portion of the ship was towed clear of the rocks. Then the extraordinary character of the work of the salvors was apparent, for it seemed that the cleavage was so smooth that it might have been accomplished by a cyclopean guillotine. As the wind and cross swell of the sea did not seem to diminish, no time was lost in getting the salved portion of the liner in tow for Southampton. Had her condition been critical she would have been towed to the nearest available port, Falmouth, where she would have been run on a sandy beach, as the dry-docks there are not of sufficient capacity to accommodate such a large vessel. The salved portion of the *Suevic,* about 400 feet in length, behaved



THE STERN OF THE SUEVIC ENTERING THE DOCKS AT SOUTHAMPTON.
(Photograph by Cribb, Southsea.)

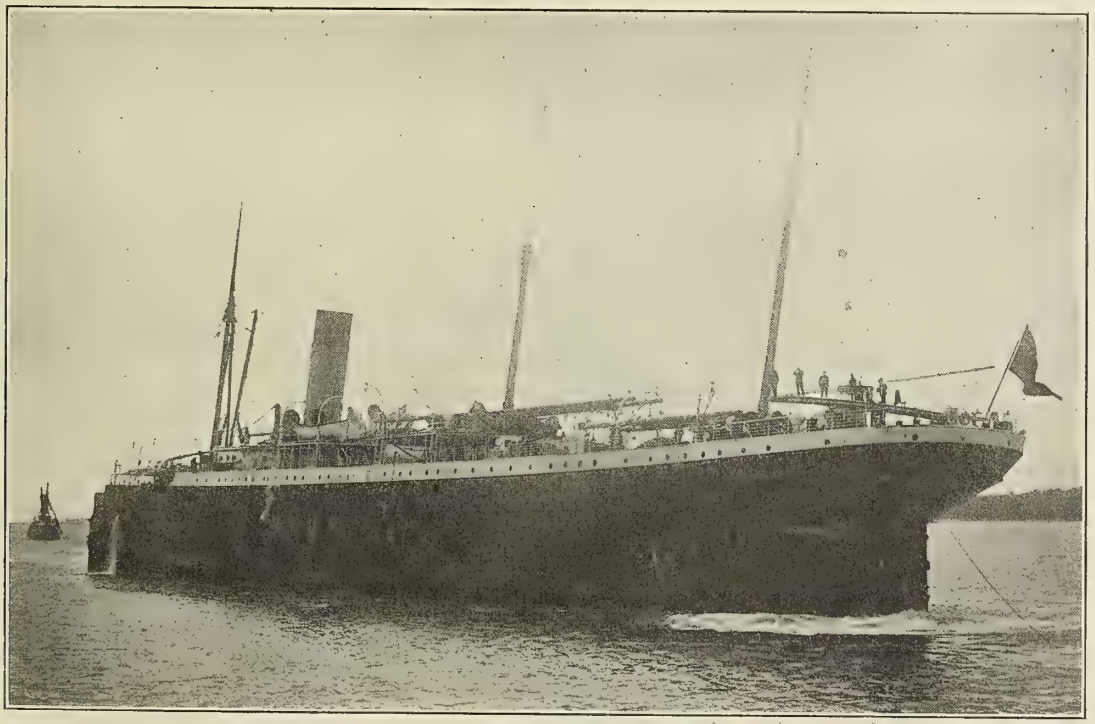
splendidly when taken in tow. The portion which remains on the rocks, approximately 184 feet of her forward part, including the bridge, stood rigid until the salved two-thirds, containing the engines and other appointments of most value, had got well out of sight. So admirable were the preparations of the salvors for the balancing of the *Suevic* that when the vessel parted she floated almost exactly on an even keel.

The procession with the salvage to Southampton was a striking one. When clear of the rocks the tugs *Ranger* and *Herculaneum* took up the work of towing, with the tugs *Blazer* and *Linnet* astern to steer the hulk. Slow progress was made, the weather being dirty. Had the weather been favorable, the tugs would have taken their prize around the Land's End, and thence to Milford Haven or Belfast. The ship had a quantity of cargo on board, and after this was discharged the vessel was strengthened sufficiently to enable her to be taken around to Belfast, where she will have a new bow fitted by her original builders.

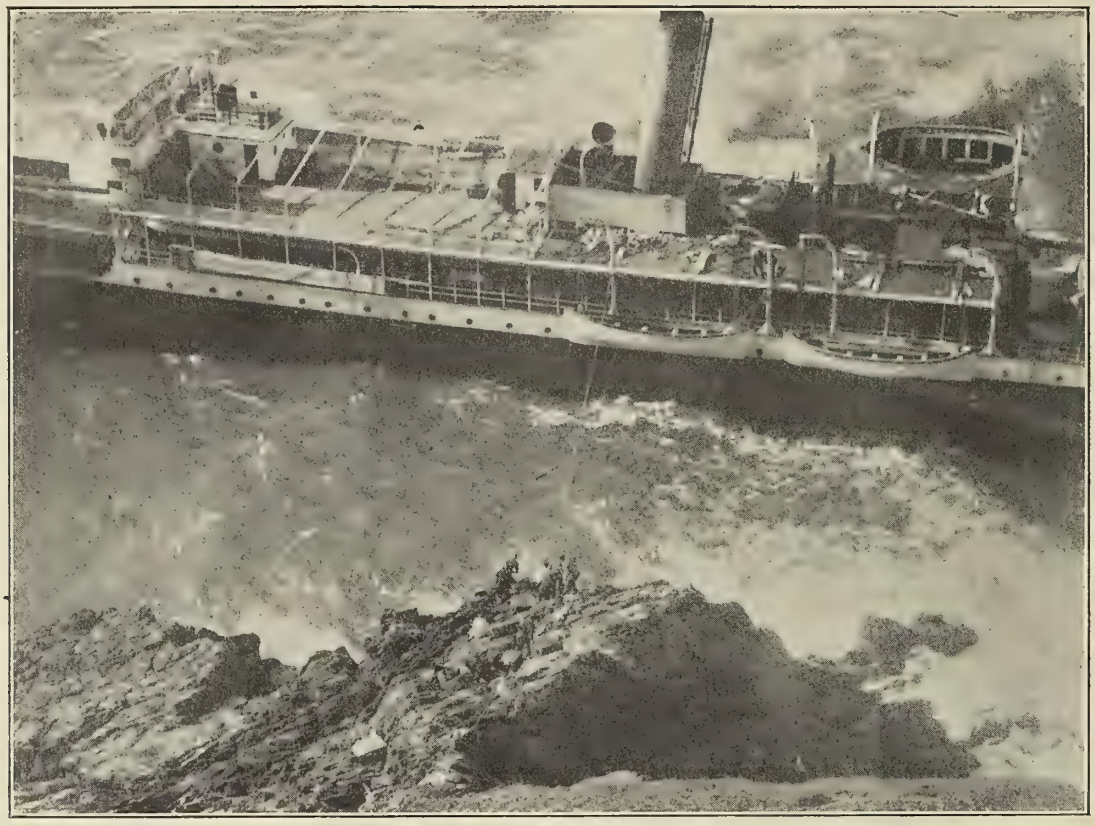
James Fisher.

Wreck of the Steamship Jebba.

The *Jebba,* belonging to the African Steamship Company, Limited (one of the Elder Dempster Lines), and trading between England and West Africa, ran ashore in a fog on the south coast of Devonshire. She carried a complement in passengers and crew of 190, and, as the character of the coast was such as to make it out of the question to use the small boats, rocket apparatus was employed, and the entire complement taken off in six hours. In the same manner baggage and cargo of all kinds



THE SUEVIC ASSISTING IN THE TOWING OPERATIONS BY USING HER OWN SCREWS BACKWARDS.
(Photograph by Cribb, Southsea.)



THE ELDER DEMPSTER STEAMER JEBBA, ASHORE OFF THE SOUTH COAST OF ENGLAND.
(Photograph, Underwood & Underwood, New York and London.)

were successfully transferred to the shore. No lives were lost, even the ship's cat and two monkeys being saved.

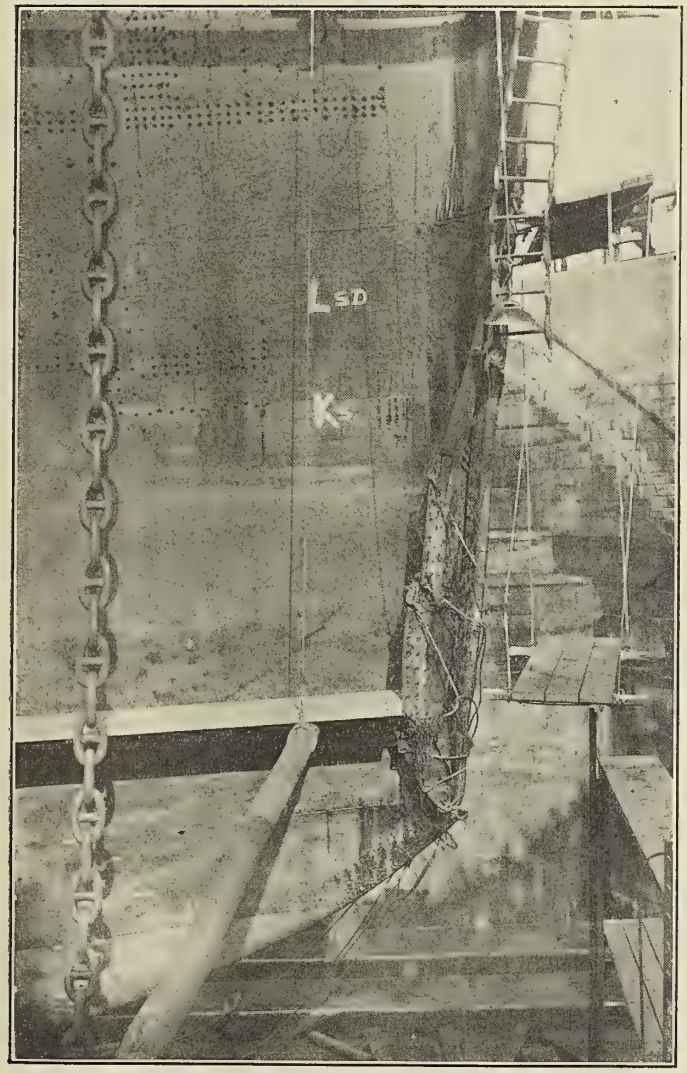
THE JEBBA ASHORE, SURROUNDED BY FLOATING PARTS OF HER CARGO.

She was steaming from Sierra Leone with a valuable cargo of 500 tons of palm oil, 800 packages of fruit, tea and coffee. When she went ashore the sea broke clear over the ship. Her bow was raised on the rocks higher than her stern. The ship was broadside on, heading eastward. There was a heavy sea running and it was impossible for any craft to get alongside. The mail bags and passengers' luggage were saturated with sea water, and much damaged. Search for luggage was extremely difficult, as all the staterooms were full of water, but most of it was rescued. The mails and other articles salved were brought to the foot of the cliffs by means of boatswains' chairs and lines between the ship and shore.

The rocks have hopelessly pierced her beneath the engine room, many of the cross-beams in the holds have given, and the stanchions also are broken; so that the hull is in a state of collapse, and the first storm will turn the vessel into a heap of debris. As it is, the ship fills at high tide. Divers at work in her holds secured the packages to tackle, by which the casks of palm oil, etc., were hauled on deck. Owing to the heavy seas, it was impossible for the lighters to lie alongside the wreck, and so the salved packages were thrown overboard and hauled up to the lighters on ropes.

The vessel was firmly wedged on the rocks, close to the shore, as our illustrations show, and has become a total wreck. She was rigged as a two-masted schooner, with derrick booms for the manipulation of cargo, and was built in 1896 by Sir Raylton Dixon & Company, Limited, of Middlesbrough. The length was 352 feet, with a beam of 44 feet 2 inches and a depth of 23 feet 4 inches. The tonnages were respectively 2,439 net and 3,813 gross. There were seven watertight compartments. Propulsion was by one propeller and a triple expansion engine, furnished with steam at a pressure of 180 pounds per square inch. The engine had cylinders with diameters 27, 43 and 72 inches, and a stroke of 48 inches.

LOOKING TOWARDS THE STERN ON THE UPPER DECK OF THE STEAMER CITY OF CLEVELAND.



THE DAMAGED BOW OF THE DEUTSCHLAND.

The Loss of the Steamer City of Cleveland.

A splendid new passenger steamer for use between Detroit and Cleveland on Lake Erie was destroyed by fire on the morning of May 13, with a loss estimated at about $700,000 (£144,000), fully covered by insurance. The steamer was being constructed by the Detroit Shipbuilding Company, and was to have gone into commission on July 1; the estimated cost when completed being about $1,250,000 (£257,000). The boat was 440 feet long and 92 feet wide, being the largest side wheel steamer in the world.

The Damaged Hamburg-American Liner Deutschland.

The great weight and the tremendous momentum of large ocean liners when under way make it necessary that the greatest care be taken in docking these great ships, for damage is done to not only the boats, but the piers, in case of the slightest collision.

The illustration shows the severe damage sustained by the Hamburg-American liner *Deutschland,* due to a collision with the pier in Dover harbor.

The ship was repaired at Southampton, requiring a new stem and about forty bow plates. The work was carried on continuously, both day and night, by the use of electric lights and the latest forms of labor-saving machinery, in order that the dry-docking might occupy as short a space of time as possible. This work was carried out by John I. Thornycroft & Co., Ltd., of London.

The New Keyham Docks. One of the most important naval dockyards in the British Empire has recently been opened at Keyham. The works cover an area of 120 acres, the most prominent feature of which is a closed basin of deep water covering 35½ acres in extent, and communicating with three docks each 740 feet long, 95 feet wide and from 45 to 55 feet deep below the coping. The docks and basin are inclosed by a massive quay wall, 4,700 feet long and 35 feet broad at the base. On the land side the defense is a semicircle of fortresses, similar in many respects to those at Port Arthur, and situated at some distance from the works. The sea defenses are also very strong. The cost of the new dry-docks has been estimated at about £4,600,000 ($22,500,000).

THE INFLUENCE OF MACHINERY ON THE GUN POWER OF THE MODERN WARSHIP.*

BY JAMES MCKECHNIE.

The aim of this paper is not so much to review the great work of successive artillery engineers who have done such splendid service in the development of ordnance machinery, as to analyze the design of all machinery so far as it affects the fighting efficiency of the latest types of warships, in order that there may be a free interchange of opinion between naval officers and constructive engineers. The influence of machinery on the gun power of the modern ship is:

(1) direct so far as it relates to the supply of ammunition to the gun, and to the training, elevating, loading, and firing of the gun; and

(2) indirect, so far as it influences the position of the guns on board ship—a matter of increasing importance.

The latter part of the subject may take precedence, as it raises important general questions which, although not perhaps germane to the title of this paper, cannot be altogether neglected. But it may be well to say at the outset that it is not proposed to deal with the speed of ships. The engineer is not called upon to settle the question of the tactical advantage of 21 knots as against 18 or 19 knots, although it must be admitted that the increase in engine power necessary to give the higher speed involves more room in the ship, and thus may tend to affect the position of the guns.

We are told, however, that the practice is to primarily regard the ship as a floating battery, and that, in evolving the design, the offensive power is the first paramount consideration. This may affect the length of the ship, apart altogether from speed considerations, in order to secure the most effective disposition of the guns in the longitudinal line. Accepting this view for the sake of argument, presuming that it involves a more or less arbitrary decision as to the length of the ship, speed, protection, and endurance become secondary, but are still more or less competitive qualities. In such a vessel as the *Dreadnought,* the direct reduction in weight of propelling machinery for a decrease in speed from 21 to 18½ knots would be about 700 tons. This difference in weight might have permitted two more 12-inch guns with their ammunition to be carried, if placed within the citadel for barbette protection.

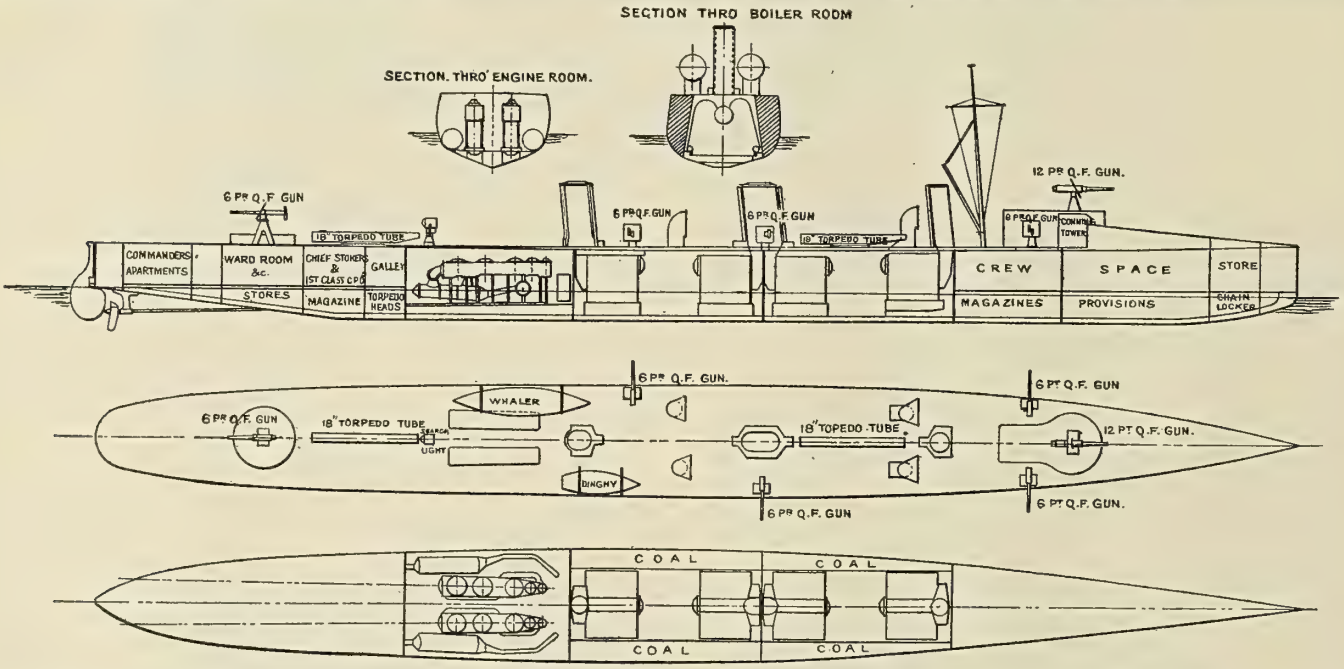
*Read before the Institution of Naval Architects, March 20, 1907.

MACHINERY INTERFERENCE WITH THE POSITION OF GUNS.

But, as has been said, the point under consideration is not so much the tactical advantage of higher speed, as the question of the space occupied by propelling machinery. This question is the more urgent in view of the decision to adopt only the largest caliber of gun for the primary armament in ships. As this limits the number of guns for the weight allowed for ordnance, it becomes more necessary to make fuller use of the weapons by giving each the greatest possible arc of training, and to insure the highest percentage of hits within a given time. In other words, if only large caliber guns are to be used, involving considerable weight for the machinery for manipulating them, every gun must be so placed as to enable it to fire on either broadside, and at the same time to give the maximum of bow and stern fire.

To the ordnance officer, the space required for the propelling machinery creates difficulties because the position of the boilers, as well as of the engines, can be modified only to a very limited extent. Moreover, the presence of uptakes and funnels seriously interferes with the gun arrangement. This objection was not serious so long as the armament included large guns at the bow and stern only, with secondary weapons along each side, supplied with ammunition from suitable passages to the magazines forward and aft. But, with all the guns of large caliber, involving training and elevating machinery as well as ammunition hoists requiring a large area of considerable depth, the limitations on the effective placing of the guns on board have been intensified, apart from the obstruction offered to wide angles of fire presented by uptakes and funnels.

Engineers must, therefore, recognize the necessity for some modification to meet the new conditions. It may be urged that such a recognition is premature, but even if the development in ordnance now projected is not permanent, the tendency must be towards the adoption of more guns of large power. It is significant, too, that with only one or two exceptions, all the first class powers have followed the British example of adopting exclusively large guns in a primary battery, and the arguments by Lieut.-Commander Sims in his report on the all big one-caliber gun ship, published in *Engineering,* on January 11 last, afford justification for favoring all 12-inch guns, instead of a combination of 12-inch and 10-inch or 9.2-inch guns. The weight of a pair of 10-inch guns, with their barbette mountings, is but slightly more than half that of a pair of 12-inch guns with their mountings, but the armor protection and space involved do not show such



THIRTY-KNOT TORPEDO BOAT DESTROYER AS ORDINARILY CONSTRUCTED, WITH RECIPROCATING STEAM ENGINES.

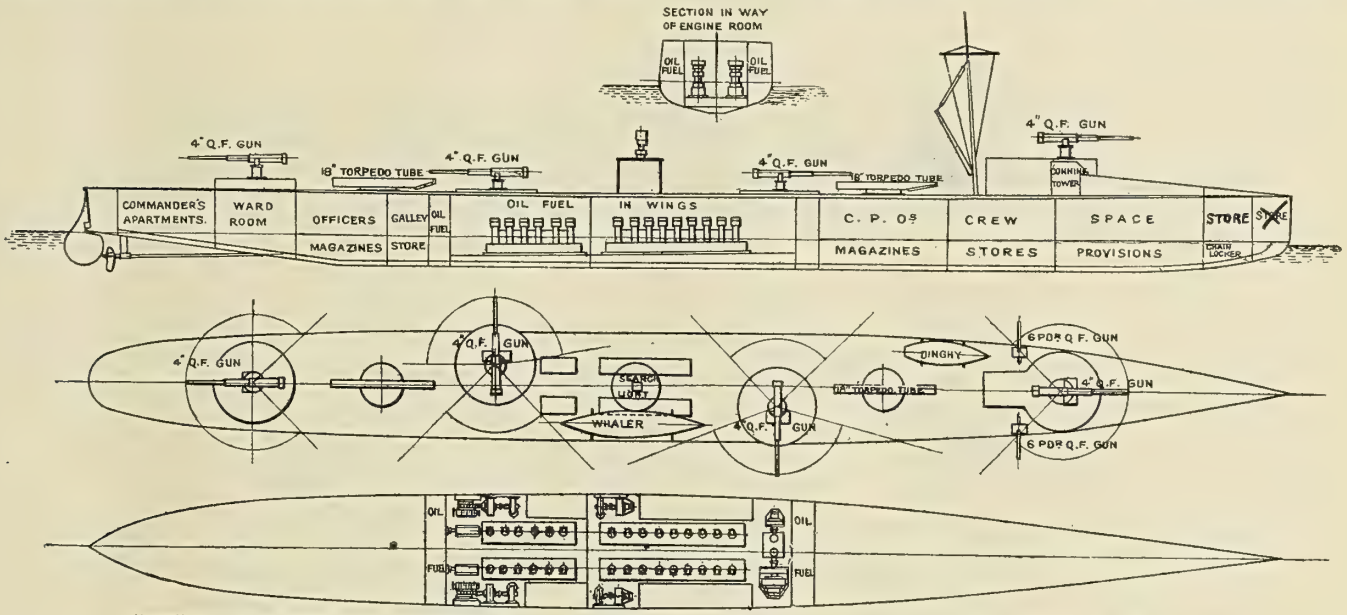
proportional difference, and the cost alike in men and power is not strikingly in favor of the 10-inch gun. The striking energy of the 12-inch gun, however, is enormously greater, so that the balance of advantage seems to favor the all 12-inch gun battleship.

This, however, is only incidental to the main consideration of the duty of the engineer—to evolve arrangements that will meet the demands of others, as his claim alike on the displacement and on the available space in a warship is subservient to the dominant requirements of the ordnance officer. This raises the important question as to whether the adoption of internal combustion machinery would not affect such advantage, from the point of view of fighting efficiency, as to induce naval authorities to encourage the application of this prime mover.

Interesting papers have already been read before the institution on the possibility of applying oil or gas engines for the propulsion of torpedo boat destroyers.* They dealt with the problems connected with the engine only, and not with the effect on gun power. In this paper, however, it is proposed to deal more with the influence of the adoption of such internal combustion engines on the gun arrangement of ships. Plans are given, showing the application of gas engines to a battleship, and of oil engines gas direct to the engines, as there is no necessity to pass it through a scrubber, or any other cleansing apparatus. There is thereby insured the maximum of heat in the engine itself, since none of it is wasted in the process of cleansing. The cycle upon which the engine works renders it possible also to recover the heat of the exhaust gas and to utilize it in the engine. A gas pump is unnecessary, so that one of the chief objections to the two-stroke cycle engine is thereby eliminated.

The compressed air plant may be located in any part of the ship. From it one main leads direct to the propelling engines and another to the pressure gas producers. The steam required for keeping down the temperature in the producer, and for preventing the formation of clinker, is generated in association with the compressed air. The possibility of poisonous gases exuding from the mains has been carefully considered, and the supply pipes, as well as the producers, are jacketed with compressed air, with which the gas escaping from the inner pipe passes to the producer or the engine.

An important feature is that the engine may be worked either by gas or heavy oil, so that coal may be stored in the bunkers and oil in the double bottom. This gives a duplication which is



THIRTY-KNOT TORPEDO BOAT DESTROYER, FITTED WITH INTERNAL COMBUSTION ENGINES, AND CARRYING A HEAVY BATTERY.

to a torpedo boat destroyer, and with these are corresponding drawings for similar types of ships of exactly the same size, but fitted with steam machinery. The success which has attended the application of the Parsons steam turbine, not only in battleships and cruisers, but especially in torpedo craft, suggests that the fullest advantage will be realized by the development of the same system using gas, or preferably oil, so that steam boilers might be entirely dispensed with.

MARINE INTERNAL COMBUSTION ENGINES.

Before referring to the designs of the ships with steam and internal combustion engines, brief general reference may be made to this type of prime mover. At the Vickers works at Barrow-in-Furness there have been constructed internal combustion marine engines of a power equivalent to about 40,000 indicated horsepower, and for three or four years almost continuous research work has been undertaken. The experiments have led to the adoption of a two-stroke cycle gas engine possessing satisfactory features. This engine may be worked either by producer gas, heavy oil, or compressed air. It may be made reversible as easily as the steam or compressed air engine. It is possible to use in conjunction with it pressure gas generators, which deliver their always desirable. The change from gas to oil may be made almost instantaneously. With oil the engine may be started when cold within a few minutes; this would be an important tactical advantage in warships. The compressor and producer plants are governed automatically, according to the consumption of the propelling engines.

STEAM VERSUS OIL ENGINES FOR TORPEDO BOAT DESTROYERS.

The drawings illustrate a 30-knot torpedo boat destroyer with steam machinery; and a vessel of identical dimensions and speed, driven by engines using oil having a flash point of about 200 degrees Fahrenheit. An auxiliary oil engine would drive an electric generator to provide current for motors to operate steering and anchor gear, the bilge pumps, and other machinery on board.

The steam-driven destroyer illustrated is one of many in the British service, and, in showing the adaptation of the internal combustion engine to a corresponding boat, it has been considered preferable to indicate the effect on gunfire rather than to utilize the economy in weight and space in reducing the size of the vessel, or in increasing the speed. Instead of having only one 12-pounder and five 6-pounder guns, the oil-driven vessel is fitted with four quick-firing guns of 4-inch caliber, and two 6-pounder guns. Both vessels have two 18-inch torpedo tubes. The quantity of ammunition—the number of rounds per gun—has not been

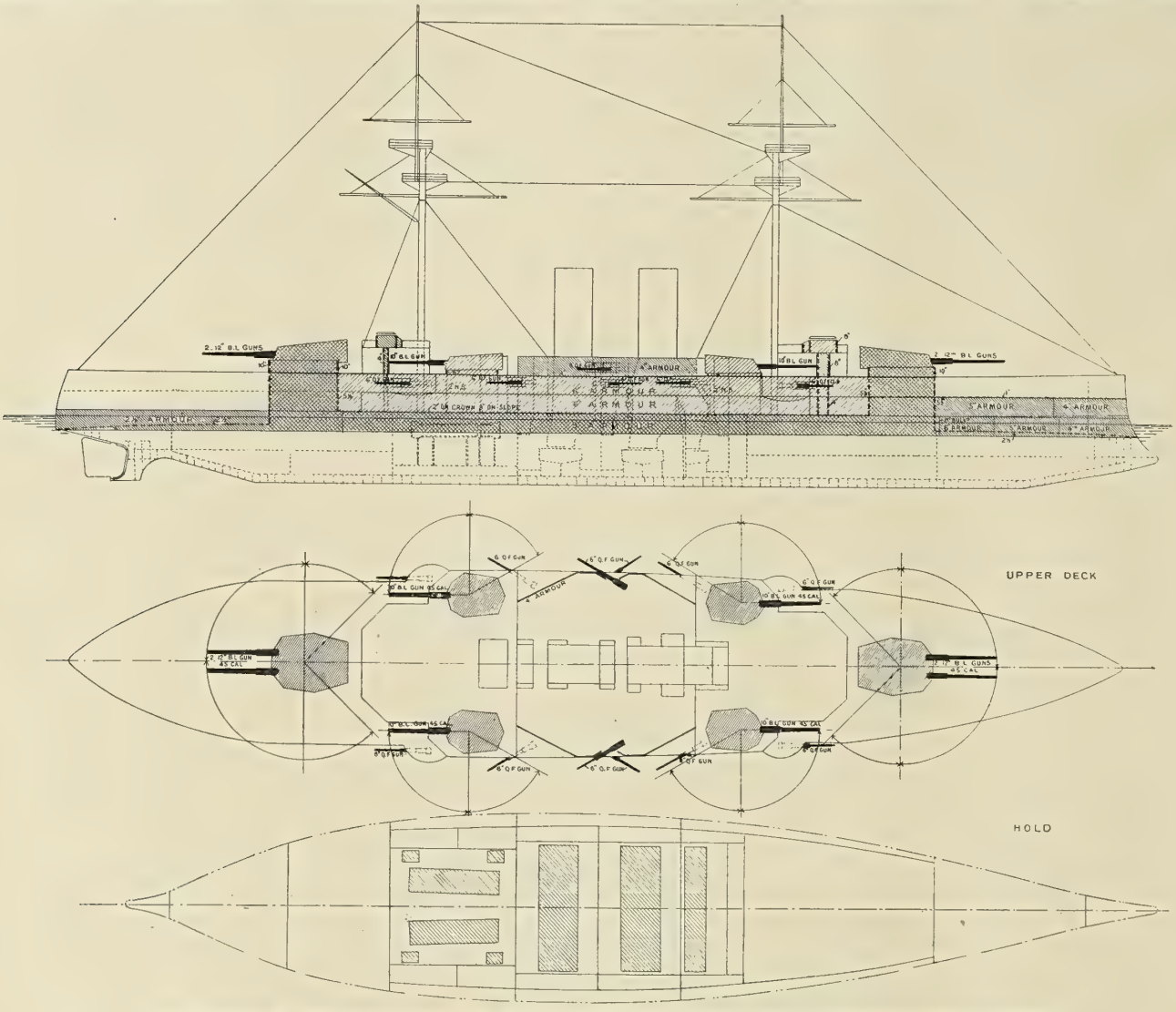
Transactions, Institution Naval Architects, Volume XLVI, pages 145 and 151, and Volume XLVIII, page 105.

reduced, although the guns carried are of greater caliber. There are 100 rounds for each 4-inch gun, 100 for the 12-pounder, 300 for each 6-pounder. A sufficient quantity of fuel has been allowed to give the oil-driven vessel, at the full speed of 30 knots, a radius of action six and a half times greater than that of the steam-driven destroyer, with full coal supply. The increase in space for the accommodation of the crew will be appreciated by a glance at the plans.

The absence of funnels and their fittings enables the guns to have a much wider arc of training. There is usually much smoke and sometimes flames from the funnels of steam-driven destroyers, especially when running at full speed, and the absence of the ship. The gas producers, of the pressure type, occupy the two center compartments. In the forward compartments there are four sets of air compressors driven by gas engines.

Heavy oil engines would be used for driving the electric generators for lighting the ship, and for supplying current to motors for working the steering and anchor gear, the ship's pumping machinery, etc. This electric generating plant could be fitted in any position in the ship found most convenient.

As of some interest, although not vital to the consideration of the influence of this machinery on the gun power of warships, the approximate weights of steam, gas, and oil machinery of a 16,000-horsepower battleship are given. These figures would, of



THE FIRST-CLASS BATTLESHIP KATORI, OF THE JAPANESE NAVY, FITTED WITH RECIPROCATING STEAM ENGINES.

these in oil-driven craft would render them less liable to detection in war. Experience with six-cylinder oil engines at the Vickers works shows that there will be less noise than with the reciprocating steam engine.

STEAM VERSUS GAS ENGINES FOR BATTLESHIPS.

The Japanese battleship *Katori*, constructed at the Vickers works, may be compared with a design of a corresponding vessel fitted with the producer gas engines already described. The advantages alike in weight, space, and arrangement, resulting from the use of the gas machinery, have been utilized to improve the gun power.

The gas machinery is divided into three groups, accommodated in six compartments. The ship has four propeller shafts, each driven by a 10-cylinder vertical gas engine. Two of the sets of engines are placed, side-by-side, in the fore-and-aft line, in each of the after compartments. The engines are purely for propelling

	Steam Engine	Gas Engine	Oil Engine
Weight of machinery, including usual auxiliaries, but not deck machinery	1,585 tons*	1,105 tons†	750 tons‡
Indicated horsepower per ton of machinery	10·1	14·48	21·33
Area occupied by machinery—engines and boilers or producers	7,250 square feet	5,850 square feet	4,110 square feet
Area per indicated horsepower	0·453 square feet	0·366 square feet	0·257 square feet
Fuel consumption in pounds per indicated horsepower per hour—			
At full power	1·6	1·0	0·6
At about one quarter full power	1·66	1.15	0·75

(*) Includes water in boilers.
(†) Includes water in jackets and piping, but not coal in producers.
(‡) Includes water in jackets and piping.

course, be subject to alteration when the details of design are made to meet specified conditions.

A reference to the steam-driven battleship will show that this vessel was fitted with four 12-inch, four 10-inch, and twelve 6-inch guns—the most effective combination of ordnance in any warship up to 1905. In the new ship it has been found possible, without increasing the length or displacement, to introduce five pairs of 12-inch guns, and to carry eighteen quick-firing guns of 4-inch caliber for repelling torpedo attack.

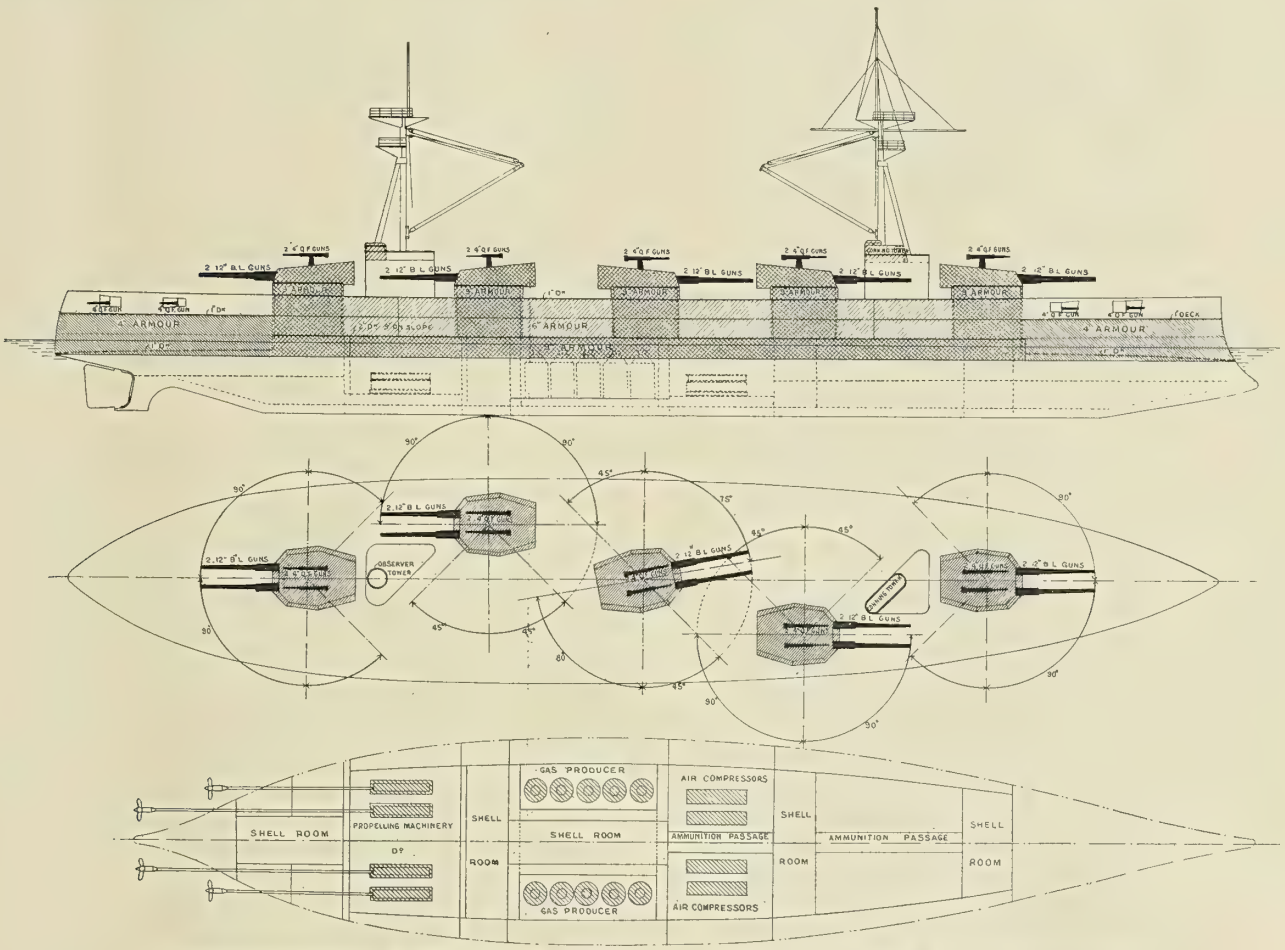
Reference to the plan of the machinery and magazine arrangements will establish the advantage of the gas system. Here we have each of the main magazines located immediately under the pair of guns which it is intended to serve. Moreover, there is communication between the various ammunition and shell rooms. This has the important advantage of enabling ammunition to be distributed throughout the ship with the greatest facility, all on one level. In the event of any turret being put out of action, the ammunition reserved for the guns in it could be used for other weapons, all being transported below the armored deck.

The benefit derived from the abolition of boiler uptakes and funnels is still more marked. It enables the turrets to be so disposed, without increasing the length of the ship, as to admit of all the ten guns being fired on either broadside. This more fully realizes the demand for "all-round fire" for all guns than is the case in any existing ship. It will thus be seen that the internal combustion engine installation allows a much greater range in the gun distribution, and is more adaptable to a reasonable arrangement of magazines, than is the case with steam machinery. Moreover, the temperature in the machinery room is lower, and fewer difficulties are involved in the satisfactory heat isolation and ventilation of the adjacent magazines.

In comparing the designs, it should be kept in mind that the object is to eliminate any other variant than machinery and gun power, although the actual weight of protective material has been increased. The second design is not put forward as representing an ideal battleship. In producing a design it is, of course, necessary to give attention to other considerations than that of gun power. Thus, part of the saving of weight and of space could be utilized for decreasing the size of the ship, while maintaining the same armament and protection as in the steam-driven battleship. Or the weight saved might be used for increasing speed by fitting more powerful machinery, although in this particular case an increased speed would be more economically realized in association with increased length of hull.

The design, however, clearly shows that greater gun power, and a fuller utilization of such offensive power, is possible with the internal combustion engine. The machinery is at a lower level in the ship, and is, consequently, better protected. As the power per unit of weight of fuel consumed is greater, the radius of action for the same allowance in displacement would be greater.

(To be concluded.)



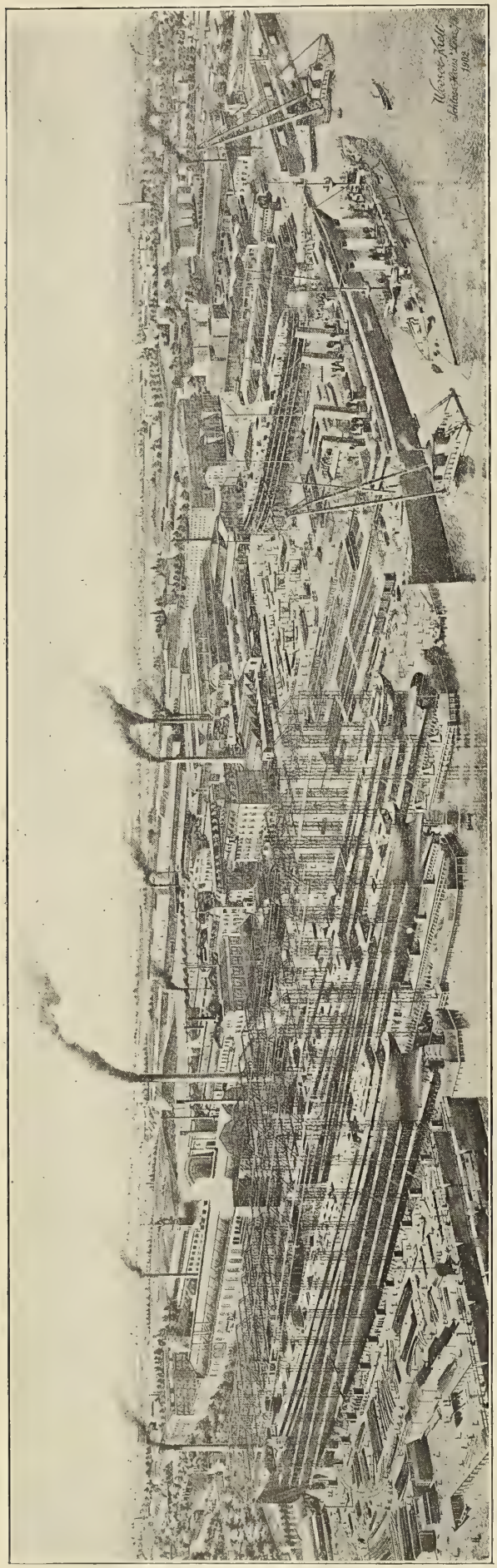
FIRST-CLASS BATTLESHIP OF THE SAME SIZE AS THE KATORI, FITTED WITH PRODUCER GAS PROPELLING ENGINES.

The Austrian Merchant Marine.

Recent figures show a remarkable growth in the steam tonnage belonging to citizens of Austria, with correspondingly great shrinkage in sail tonnage. The figures may be given as follows:

	Sail Tonnage.		Steam Tonnage.		Total Tonnage.	
1871	3,023	311,276	91	49,977	3,114	361,253
1903	1,596	66,601	322	499,234	1,918	565,835
1907	1,517	54,028	390	605,632	1,907	659,660

It will be seen that during the thirty-six years comprised in these figures sailing tonnage has fallen off from 311,276 to 54,028 tons, which represents a loss of 83.4 percent. During the same period steam tonnage has increased from 49,977 tons to 605,632 tons, this gain representing no less than 1,111 percent. The average size of sailing vessel has fallen from 103 tons in 1871 to 41 tons in 1903 and 36 tons in 1907. The average size of steamer has increased from 548 tons in 1871 to 1,552 tons in 1907.



GENERAL VIEW OF THE PLANT OF THE STETTINER MASCHINENBAU-ACTIEN-GESELLSCHAFT VULCAN, ONE OF THE LARGEST SHIPYARDS IN GERMANY.

GLIMPSES INTO SOME GERMAN SHIPYARDS.

BY HAROLD A. EVERETT, S. B.

In general the German shipyards are now developed to such an extent that they are almost, if not quite, capable of supplying all the requirements of their own country. This excellent condition has been obtained largely by the judicious assistance furnished by the German government, and by the enterprise of the leading German steamship lines, which has supplemented the government in providing orders for vessels of the highest speed and most improved equipment. The yards readily fall into a dual general classification, namely, those bordering on the North Sea, and those launching into the Baltic Sea or its tributary rivers; and though both districts turn out a wide range of classes of ships, we find the majority of the government work coming from the Baltic yards, while the major part of the merchant work, especially ships of moderate speed, is turned out from the North Sea district.

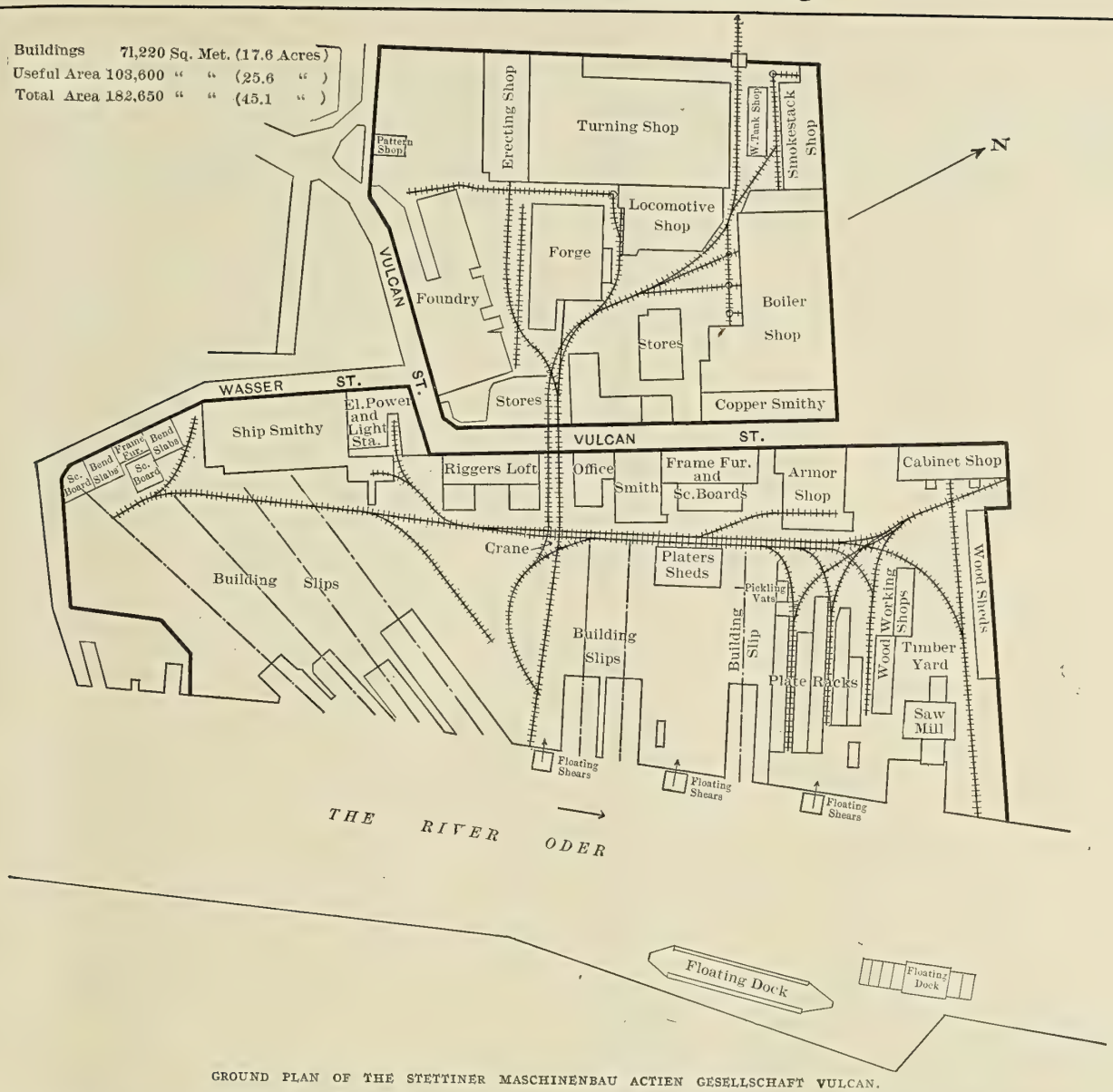
The average of wages varies with the locality, wages being highest in the seaports of the North Sea, and lowest in the more easterly districts of the Baltic. Of course, in Germany, as everywhere else, the yards located in large cities, or closely adjacent to them, are forced to pay higher wages than those near small towns, but this is one of the expenses incidental to an urban location. There is no uniformity in the relation between the number of technical staff and workmen employed, and tonnage and indicated horsepower of output, and consequently small chance of any accurate comparison; but, generally speaking, there is a larger technical staff in yards where warships and fast passenger vessels are constructed. Nearly all the yards of importance control engine works, and in most cases these are within, or immediately adjoining, the shipyard; a noticeable difference from the British yards, where few, except the largest plants, have the engine works in the shipyard.

THE VULCAN YARD.

Probably the most famous yard in Germany is that of the Stettiner Maschinenbau-Actien-Gesellschaft "Vulcan," better known as the Vulcan Company, located just below Stettin, where most of the large express steamers of the Hamburg-American and North German Lloyd steamship companies have been constructed. This yard was founded in 1851, under the name of Fruchtenicht and Brock, and so continued up to 1855, when, having taken a contract for three sister ships, which proved too much for it to handle, the company sold out to the present stock company (1857), which was then capitalized at $750,000. This has since been increased until at present it is approximately $2,000,000. In 1871 this company took the contract for the large German warship *Preussen* (6,770 tons displacement), which was satisfactorily completed, and from this time work increased rapidly. At present the company employs about 7,500 men, as against 1,800 in 1871, and now covers 75 acres, where 20 acres formerly gave it ample room.

The yard is thoroughly modern and well equipped in all departments, and has especially good facilities for handling large work. It belongs to the Baltic group, fronting on the river Oder. A glance at the plan shows at once the almost complete segregation of the engine and hull departments, though both are, of course, under one managing head. The hull department has the area from Vulcan street to the river, while the engine department occupies the land on the other side of the street. There are seven building slips, three small ones at right angles to the river, and four large ones at the southern end of the yard, launching down stream.

The large slips have a complete steel working equipment (frame furnaces, platers' shed, ships' smithy, etc.), at their heads, and this is duplicated, though for lighter work, at the heads of the small slips. This duplication allows the two classes of ships to be worked independently, each to its best advantage, and with the desirable economy of using tools powered for the weight of steel

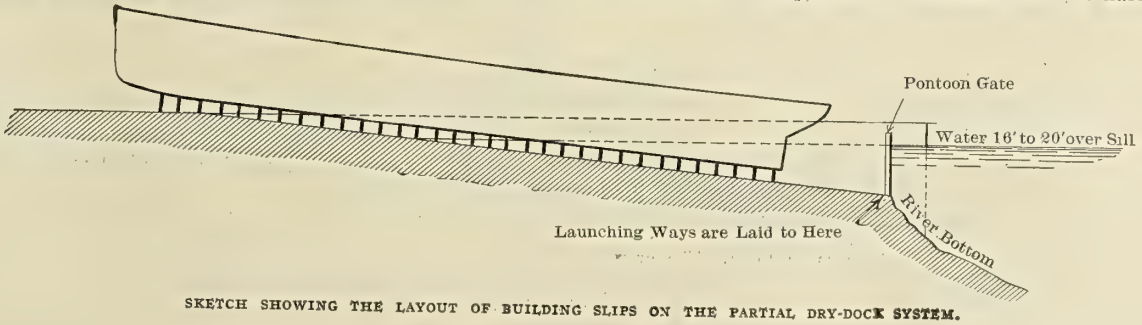


GROUND PLAN OF THE STETTINER MASCHINENBAU ACTIEN GESELLSCHAFT VULCAN.

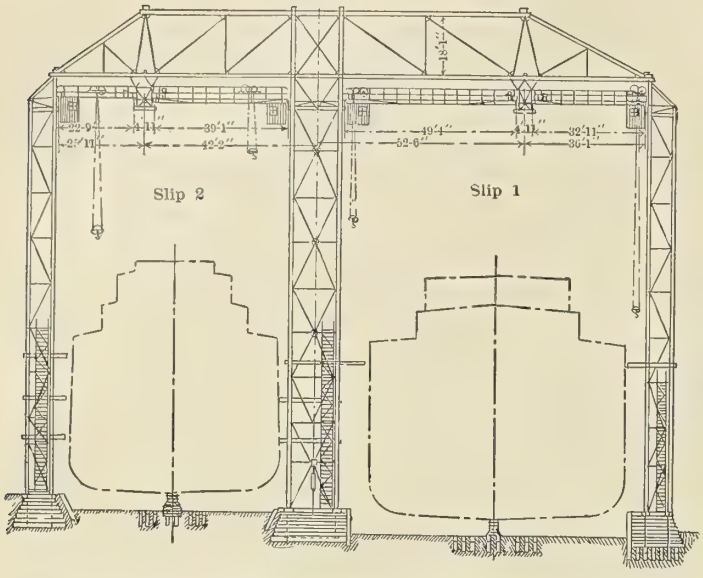
being worked. The progress of material from plate yard to ships is fairly straightaway, though for the large slips the distance is great. The plate yard is served by three locomotive cranes.

The slipways are laid out in the manner customary throughout this part of Germany, *i.e.*, with the lower end about sixteen or twenty feet below the level of the water, and fitted with a removable pontoon or cofferdam to keep the water from going into the slip; this in effect makes it a partial dry-dock. At launching, after the ways have been laid, this cofferdam is removed, the water rises till the ship is partly waterborne, and then the launching takes place in the customary manner, except that the ship slides only a comparatively short distance. The object of this arrangement is to do away as much as possible with submarine work when laying launching ways, and to minimize the distance the vessel slides during the launch. There are no tides on the Baltic, which necessitates much more under-water work when laying ways over the ordinary slip than in the United States, where there is from eight to eighteen feet difference of elevation between high and low tides. The slips are seldom carried further out than this, as it is desirable to have the ship attain considerable velocity down the ways by the time pivoting occurs, in order that this unstable position may be passed by quickly; for if the slips were deeper, with sufficient rise of water to lift the ship from the blocks without any sliding, pivoting would be greatly prolonged, and there might be danger of the ship rolling over sideways.

The four large slips are covered by steel skeleton sheds, which serve as supports for the crane service, and it is here that the large express liners *Deutschland, Kaiser Wilhelm II,* etc., that have made this yard world famous, have been erected. There are two cranes to a ship, one of broad and one of narrow span, to



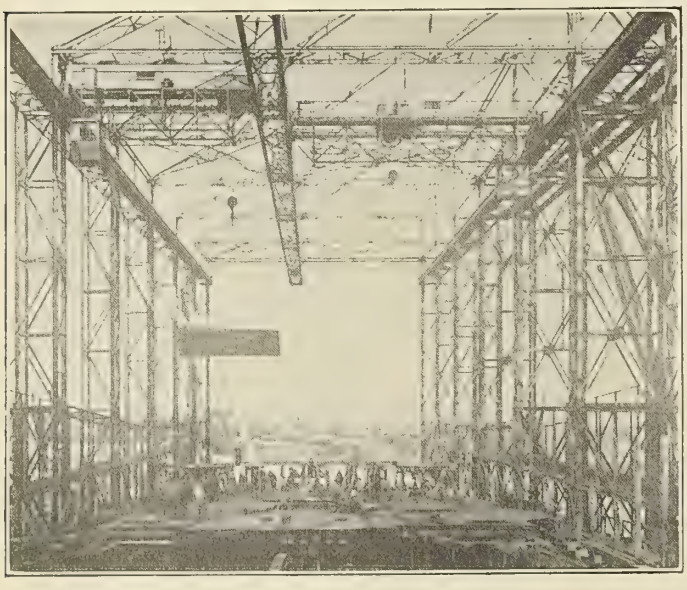
SKETCH SHOWING THE LAYOUT OF BUILDING SLIPS ON THE PARTIAL DRY-DOCK SYSTEM.



CROSS SECTION OF DOUBLE COVERED SLIP IN THE VULCAN YARD.*

throw the neutral or unreachable zone off the center line of the ship. The height of the columns is 124 feet 8 inches, and they are spaced 42 feet 1 inch centers. The principals have a maximum depth of 18 feet, and the clear headway is 124 feet 8 inches. Two of the berths have a clear width of 68 feet 1 inch; the other two are 88 feet 7 inches wide. Four-ton cranes are used, and by two working together eight tons can be placed as desired on the ship.

Extending down the sides of the slips at frequent intervals are independent punches and shears for the convenience of the fitters, and to save the time which would be lost in carrying work to and from the shops at the heads of the slips. In slips as large as these this arrangement is a great economy, and the same plan



INTERIOR OF ONE OF THE VULCAN SHED SLIPS.

is held to throughout the yard, which is dotted with isolated tools, each protected by a small umbrella shed. Pneumatic tools are extensively used, and most of the merchant ships are built of the common "solid floor on every frame" type, a good many having joggled plating. Joggled frames are not used so extensively as in Great Britain, possibly because the builders are not so familiar with them; and, after the keel is laid, the erection of frames commences simultaneously at several points.

There are two floating docks, the largest of 12,000 tons capacity, and three sets of floating shears of 80 tons, 100 and 150 tons capacity. The shears are built on the double pontoon plan, with the counterweight traveling on the built-up girder connecting the pontoons. Both floating docks and shears are shown in the general view of the works.

Electric and pneumatic drives are used throughout the yard, and the electric equipment is very complete. At the time of the installation of electricity (1890) two 300-horsepower experimental stations were put in; one in the engine department on the three-phase system, with a voltage of 500, which was reduced in the case of the lighting circuit and small portable drills to 220 volts, and the other in the shipyard, where direct current generators of 110 volts were used. As a result of these experiments the three-phase system was decided upon, largely, however, because monophase motors had not attained to any satisfactory degree of practical success. The voltage of 500 was held to, except for work on the ships, where it was dropped to 110 for safety. Briquettes are used for fuel in the power station, and these are very cheap, costing approximately $4.10 (£0-16-10) per ton. They are manufactured from anthracite coal and are supplied by a Stettin firm. A rather elaborate device is installed for automatically weighing and recording the fuel consumed.

The approximate wages paid for certain classes of labor may be of interest:

Draftsmen with college degrees and 8 to 10 years' experience, $75 (£15-8-0) per month and upwards. Draftsmen without college degrees and 8 to 10 years' experience, $50 (£10-5-4) to $62(£12-15-0) per month. Recent graduates from the Technische Hochschule*, $30 (£6-3-3) per month. Chief engine draftsman, $150 (£30-16-0) per month. Machinists, fair, $1.12 (4/7); good, $1.50 (6/2); best, $1.75 (7/2), per day.

It should be borne in mind, in considering these wages, that living expenses in Germany are materially less than in Britain or America. The hours of labor are from 7 to 12 a.m., and from 1.30 to 6.30 p.m., for the yard; for the Technische Bureau or office, from 8 to 12 a.m., and from 2 to 6 p.m.; both for six days out of the week.

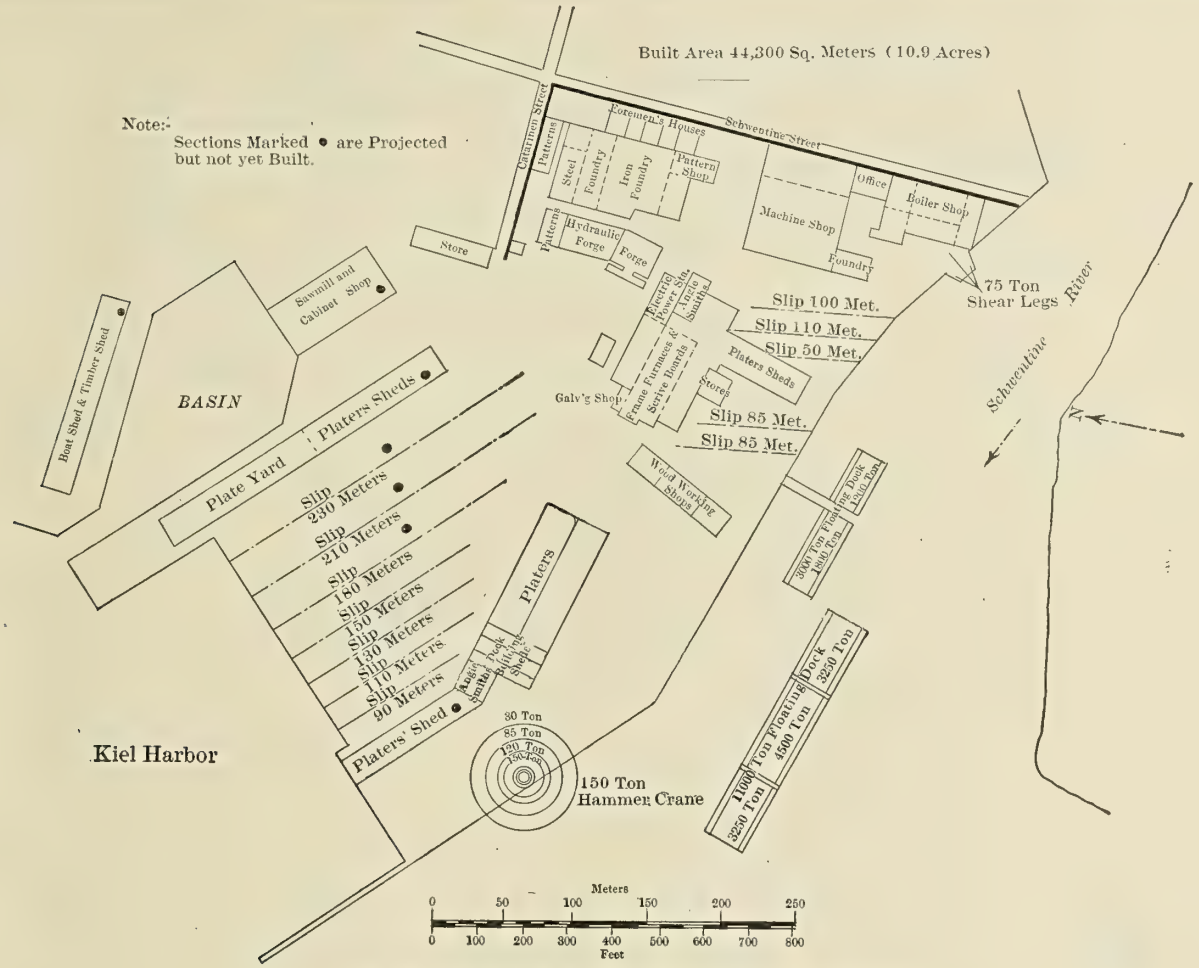
GENERAL VIEW OF THE VULCAN SLIPS FROM THE WATER.

THE HOWALDTSWERKE.

The plant of the Howaldt Brothers, known as the Howaldtswerke, is another large commercial yard, with four slips 300 to 500 feet long, five smaller ones, and three very large slips proposed, which will take vessels up to 700 feet in length. The yard is of the Baltic group, fronts on Kiel harbor, and is well supplied with floating docks. This latter is a statement which may be applied to nearly all German yards of any size, and it seems strange, in view of the cheapness, usefulness, and, judging from Germany's experience, thoroughly practical value of these docks, that they are not more widely adopted in Great Britain and America. The two docks at the Howaldtswerke are in five sections, which can be coupled together into a two-section and a

*Each crane has a capacity of 4,000 kilograms (4 tons). The greatest lift is 36 meters (118 feet). The speed of lift is 10 meters (32.8 feet) per minute; of traverse, 20 meters (65.6 feet) per minute; of crane, 80 meters (262.7 feet) per minute.

*The Technische Hochschule correspond to our first grade technical colleges.



PLAN OF THE YARD OF THE HOWALDTSWERKE, KIEL, GERMANY.

three-section large dock. The two small sections are of 1,200 and 1,800 tons capacity, and give a joint lifting power of 3,000 tons. The other three, one of 4,500 tons and two of 3,250 tons each, when united give an 11,000 ton dock.

That the yard is the result of a gradual growth from a small beginning is evident from a glance at the plan, the two eastern slips and adjacent shops being the nucleus from which the present yard grew. The newer slips to the westward are served by jib cranes, four to each, with the platers' sheds, etc., located at the head of them. The eastern end of the platers' shed is divided into three bays parallel to the centerline of the slips, and each bay is served by two 6-ton cranes for assembling and handling material. The cranes travel on tracks at different elevations above the floor, to allow passage of one by the other. The machine tools are largely of British make, and this is true throughout Germany, though rapid strides are being made by German manufacturers. There is a large outfitting crane of the hammer type (150 tons) on the eastern sea wall, and a pair of 75-ton sheer-legs closely adjacent to the boiler shop, for installing the machinery.

A unique feature of this yard is the extensive steel casting business carried on in conjunction with the shipbuilding. The blays punched from the plates, when mixed with ordinary scrap in the ratio of three to one, give a very good quality of steel for castings. Practically one-half of the output from this department is used in the shipyard. Rolling mills for plates are controlled by this yard, the plates costing about $25 (£5-2-9) per ton, and it is proposed to run a mill for shapes, as much trouble has been experienced in obtaining them. There is apparently sufficient demand in this district to make it easy to dispose of the stock not needed by the yard itself.

(To be concluded.)

Propeller Struts.*

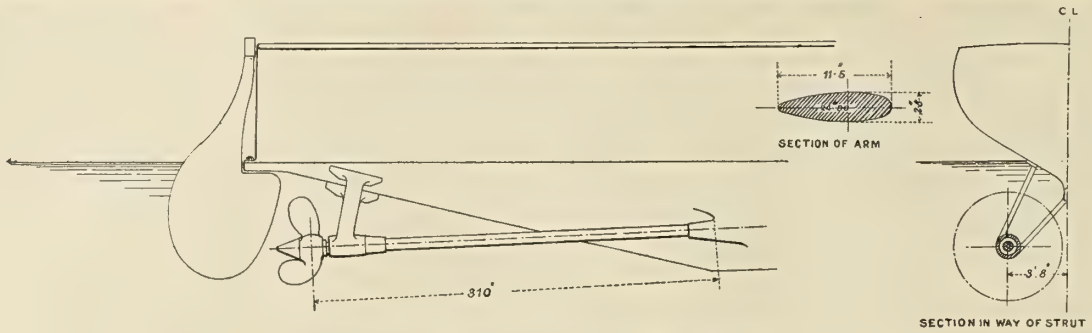
BY GEORGE SIMPSON.

The subject of suitable area for propeller strut arms is one which, so far as the writer is aware, has not hitherto been dealt with in the transactions of this or kindred institutions, and has, for some reason or other not explained, been omitted from the rules of the classification societies to whose requirements so great a proportion of our vessels are built. With the introduction of turbines for marine propulsion, and the consequent increase in the number of shafts, coupled with the fact that these structural fittings are of at least equal importance to rudder stocks, whose diameters have always been the subject of specific requirements, the subject of proportional sizes for these struts becomes worthy of interest. The object of the paper is to induce discussion on a semi-empirical formula, whose function is the determination of suitable dimensions for strut arms by a definite method, with a view to insuring proportional relationship between the area of arm, the horsepower transmitted, and the overhang of struts.

The present almost general practice of proportioning these directly on the horsepower and previous experience, or in many cases individual opinion, has resulted in widely divergent results for similar work. This is probably more particularly noticeable in the size of strut arms for the larger classes of naval vessels, where in many cases, we find about twice the sectional area which would be assigned for an ocean liner of similar power, revolutions, and overhang, although structurally the naval vessels are of lighter construction. The result is that many tons of valuable material and weight are lost to the builder and owner respectively.

It would seem almost impossible to determine the stresses

*Read before the Institution of Naval Architects, March 21, 1907.



STRUTS FOR THE PROPELLER SHAFTS ON A TORPEDO BOAT.

exerted on these strut arms, although the impression at first sight tends to the view that the pressure exerted on the boss journal by the overhang of arm would give a moment sufficiently accurate to calculate an equivalent resisting moment of section with a suitable fiber stress. This view of the case, considering the bracket as a cantilever, would result in giving the greatest section modulus to the arms where they adjoin the shell palm, and tapering from thence to the junction with the hub. This was not an unusual design of struts when twin screw vessels first came into general use. The few cases, however, in which propeller struts were carried away, showed conclusively that the greatest stresses, apart altogether from accidental causes, were those induced by centrifugal forces, and were alternating ones, causing vibration to the outer part of the arms where they joined the hub. These stresses should be very slight with a perfectly balanced propeller, and would be greatly augmented by a badly balanced wheel, or in a vessel of light construction, where there is a tendency for the after part of the vessel to "wiggle." That such a movement does take place to a very appreciable amount came under the immediate notice of the writer on one of the 27-knot destroyer class having a rudder of the usual overhung type, and a stock of exceptionally large diameter and of 36-ton steel, where the distance between the side of rudder and the propeller tips was 1½ inches measured in dock, and after trial trip, on redocking, the propeller tips were found bent over and the rudder plates excoriated with contact. The deflection of the rudder as calculated accounted for only about ⅜ inch, of the original 1½-inch clearance, so that the contact of propeller and ship was in a great measure due to this "wiggling."

The formula given comprises the factors P, the horsepower transmitted per shaft; R, the number of revolutions per minute; l, the outboard length of shaft, and a coefficient varying with the revolutions, its function being the adjustment of the area solved to the varying length of strut. This function will be more evident from an example.

As one of the factors in computing P is the number of revolutions per minute, it follows that for a given power there may be a great difference in the revolutions per minute, and consequently in the diameter of propeller, the larger wheel requiring a much longer strut to hold the propeller clear of deadwood, and, on the other hand, a high turning propeller would take a comparatively short strut. It will be evident from this, that, viewed as a cantilever, the shorter strut, having the lesser bending moment, would not require so great a section modulus to produce the equivalent resisting moment. In the example stated we have taken the case of $P = 2{,}000$, transmitted through a shaft turning at 80 revolutions per minute in a freighter, and a similar power given in a torpedo boat shaft turning at 400 revolutions per minute. The outboard length l in the first case is taken at 300 inches and at 310 inches in the high speed vessel, as the latter would have much finer lines, accounting for a greater distance for the intersection of the center line of shaft with the side of vessel than would be the case in the fuller lined freighter. We then have—

DIMENSIONS OF PROPELLER STRUTS AS FITTED AND BY FORMULA.

No.	Per Shaft				As Fitted		Per Formula	
	P.	R.	l, Inches	$\sqrt[3]{P.R.l}$	$L \times B$ Inches	Area Square Inches	$L \times B$ Inches	Area Square Inches
1 C	13,000	126	648	1,020	33 × 10	259	26·2 × 6·5	128·0
2 C	13,000	123	552	959	27 × 7	148·2	25·6 × 6·4	123·0
3 C	10,500	138	668	1,037	28 × 8	172·8	25·0 × 6·2	120·0
4 S	8,000	200	289	773	20 × 3	45·0	18·1 × 4·5	61 4
5 C	8,000	154	642	925	24 × 6½	122·2	22·5 × 5·6	94·8
6 C	2,250	172	372	524	16 × 4	48·0	16·0 × 4·0	48·0
7 B	9 500	120	319	714	30 × 8	180·0	22·6 × 5·6	95·5
8 B	8,700	125·5	296	686	24 × 6½	122·2	21·4 × 5·4	86·4
9 B	8,250	120	357	714	33 × 10	250·0	22.6 × 5.6	95·5
10 B	7.600	128	321	678	24 × 6½	122·2	21·2 × 5·3	83·7
11 B	5,000	120	356	597	24 × 9	169·5	20·5 × 5·1	78·5
12 L	5,350	90	390	573	24 × 6½	122·2	23·2 × 5·8	100·6
13 C S	3.000	150	350	540	16 × 4½	54·0	17·4 × 4·3	56·8
14 C S	3,000	192	304	560	18 × 4	56·5	15·7 × 3 9	46·1
15 P C	4,700	111	360	573	18 × 4½	63·6	20·8 × 5 2	81·5
16 P C	4,600	105	340	548	18 × 5	70·6	20·9 × 5·2	82·4
17 P C	4,350	113	340	551	18 × 5	70·6	20·3 × 5·1	77·0
18 P C	4,000	235	528	792	20 × 6	90·0	19·3 × 4·8	70·0
19 P C	3,670	106	360	520	18 × 4½	63·6	20·3 × 5·1	77·5
20 P C	3.000	112	368	498	18 × 4	56·5	19·3 × 4 8	70·2
21 P C	2 600	130	290	461	18 × 4	56·5	17·3 × 4·3	56·0
22 P C	1,500	100	169	294	9 × 3½	24·7	15·6 × 3 9	46·4
23 P C	1.300	125	304	367	15 × 3½	41·2	15·6 × 3·9	46·4
24 P C	840	156	408	377	12 × 4	37·5	14·3 × 3·6	38·2
25 F	3.500	125	630	651	18 × 4½	63·6	20·9 × 5·2	82 25
26 F	2,810	125	337	491	22 × 3½	65·0	18·2 × 4·5	62.0
27 D	4,200	364	483	904	15½ × 2¼	27 0	14·5 × 3·6	39·3
28 D	2,420	370	380	698	8 × 1½	12 0	12·6 × 3·1	29·8
29 T*	2,000	375	250	572	7 × 1¾	10·0	11·3 × 2·8	24 1
30 M†	165	180	110	148	5 × 1½	7·0	8·3 × 2·0	13·0
31 R	150	400	100	181	5 × 1¼	5·5	6·2 × 1·5	7·1
32 Y	200	150	180	176	8 × 2	13·0	9·9 × 2·5	18·5
33 P*	300	600	90	253	5 × 1⅛	4·5	5·9 × 1·5	6·66
34 P*	250	500	72	208	5 × 1	4·0	5·9 × 1·5	6·6
35 P*	200	550	80	207	3¾ × ¾	2·2	5·6 × 1·4	5·9
36 P*	93	500	72	149	3½ × ⅝	1·8	5·0 × 1·25	4·7
37 P*	17	450	48	71	2¾ × 11/16	1·5	3·6 × 0·9	2·5
38 P*	10	400	42	55	2 × ⅜	0·6	3·4 × 0·85	2·2

* Single screw with vertical strut. † Strut was perceptibly too light.

C=cruiser. S=scout. B=battleship. L=liner. CS=channel steamer. PC=passenger and cargo steamer. F=freighter. D=destroyer. T=torpedo boat. M=miner. R=river launch. Y=yacht. P=pinnace.

	For the freighter.	For the torpedo boat.
Area $= \sqrt[3]{\frac{P.R.l}{\cdot 0633\,R}}$	= 73 sq. inches.	24.9 sq. inches.
Length of Section $L = \sqrt{5 \cdot 333\,\text{Area}}$	= 19.7 inches.	11.5 inches.
Breadth of Section $B = \frac{L}{4}$	= 4.9 inches.	2.8 inches.

If we assume 15 feet as the diameter of the freighter's propeller, and 6 feet 9 inches for the torpedo boat, the diagram produced will show the difference in length of strut. If we were to assume a weight for propeller and outboard length of shaft for each case and apply this weight as a deadload for the purpose of comparing the *relative* intensity of the moments acting on each, we should find a very close agreement between the ratios of these compared with the moduli of section of the arms. Of course, it must not be inferred from this that the writer claims for the formula other than what it is, viz., a rule based on observation and practice, with an attempt, as already stated, to secure a fairer relationship between the scantlings of struts and the work they are designed for.

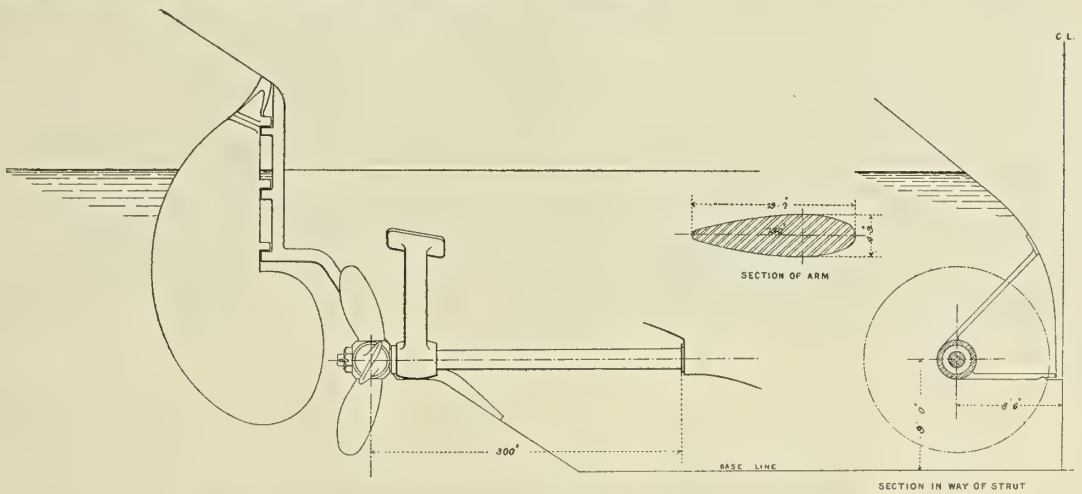
The vessel referred to on the preceding page afterwards broke both of her propeller struts with an interval of about three months between the accidents. Of course, it may not be right to attribute this altogether to the wiggling movement of the stern previously mentioned; but there can be no doubt that it may have been a factor of no small amount in causing the fracture. The original struts of this destroyer were tapered from 7 by 1½ inches to 9 by 1½ inches with a minimum sectional area, where they broke, of 8 square inches. It will be seen on reference to ship No. 28 in the table of dimensions, that, by the formula given, these struts should have been 29.8 square inches, and of section 12.6 by 3.1 inches. The other cases in which there is a great difference between actual struts and the formula are Nos. 4 and 30, and in each of these vessels there is no doubt that the struts are dangerously near the breaking point, the extreme frailty of the arms being quite observable on the ship.

In support of the statement that in many cases the area of propeller strut arms is assumed without due consideration, attention is directed to Nos. 1 and 2 in the table of dimensions, where it is shown that in almost similar cruisers a difference amounting to 75 percent is observed between the two vessels, showing that, as the lighter strut has performed its work satisfactorily on service, a weight of about 23,000 pounds of cast steel has been sacrificed by the builder, and its equivalent lost in ammunition space. This is not an isolated case, and it is borne out by many examples.

An interesting point to be noted in comparing the arms of struts required for single-screw vessels, where these are fitted vertically, is the much smaller area which the actual struts have in comparison with the formula results. With horizontal struts the case is reversed—that is, in the majority of cases the formula gives a slightly increased area over the actual brackets, except in the case of battleships and cruisers. This is probably accounted for by the fact that in the vertical position, the strut is theoretically not subjected to stresses as great as when it is arranged horizontally.

It would be extremely difficult to state theoretically what fastening is required through the palms to the shell; but an investigation of a great number of struts showed that the proportion of sectional area of fastenings to area of strut arm ranged from 0.4 to 0.55, and the writer is of the opinion that 0.5 would be a very good proportion for rivet or bolt area, and one that should give an ample margin of strength, as the stresses which these have to bear do not appear to be excessive.

In conclusion, it may be stated that the author has applied this formula for the past eight years to the determination of the propeller struts of a great number of vessels, in which the factors varied to the extremes found in such vessels as pinnaces, destroyers, scouts, yachts, freighters and liners. The table given will show how the results in these cases would have compared with everyday practice, had the scantlings been assumed in the ordinary way, the probability being that in applying the formula a considerable saving in weight would have been effected.



STRUTS FOR THE PROPELLER SHAFTS ON A TWIN-SCREW FREIGHT STEAMER.

United States Shipbuilding in April and May.

The report of the Bureau of Navigation for the month of April records the construction of 90 vessels amounting to 53,100 gross tons, or an average of 590 tons. Of this total, 16 vessels, aggregating 49,183 tons, or an average of 3,074, are steel steamers. For the first time in many months the two largest vessels in the list are intended for ocean service, they being the *Mexican* of 8,579 tons, belonging to the American Hawaiian Steamship Company, and the *Antilles* of 6,878 tons, intended for the Southern Pacific service between New York and New Orleans. Three other steamers on the list exceed 6,500 tons, all being on the Great Lakes.

Returns for May make a much poorer showing, the construction being only 27,161 tons in 107 vessels. Seven of these were steel steamers, accounting for 20,052 tons, or an average of 2,865 gross tons. The three largest vessels are, as usual, upon the Great Lakes, and make a total of 16,276 tons, or an average of 5,425.

The total construction of steamers, sailing vessels and unrigged vessels during eleven months ending May 31, 1907, amounted to 439,828 gross tons, as compared with 380,400 tons during the corresponding period of 1906, and a total of 393,291 tons for the entire year 1906. The present figure is greater than that for the entire year 1902, which was a high-water mark.

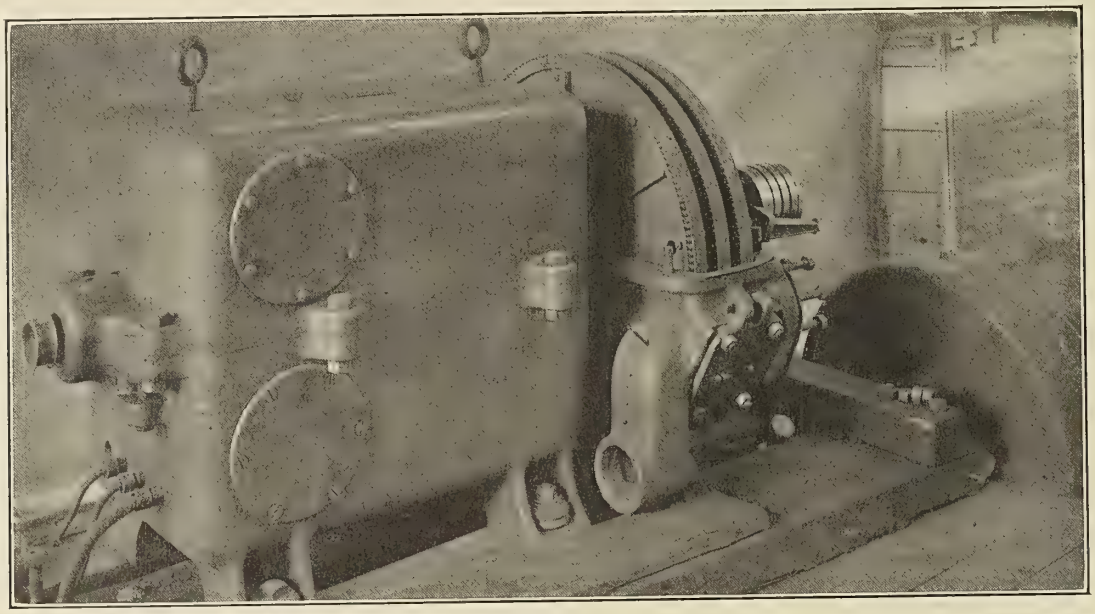
Steamships in the American-Foreign Trade.

One of our contemporaries publishes periodically the movements of all steamers engaged in the "foreign trade" to and from New York. Analyzing the tables of nationalities and tonnages, we find some very interesting results. The list published in the middle of May shows a total of 545 such steamers, aggregating 2,685,625 gross tons. Of this total, only 36 steamers, amounting to 180,634 tons, fly the American flag, while Great Britain is represented by practically one-half of the total, having 266 steamers, aggregating 1,303,333 tons. Second rank is held by Germany with 93 vessels, amounting to 592,549 tons. Other nations have smaller tonnages, and, with the exception of Norway, which has 41 steamers to 36 for the United States, the numbers are all smaller than for the three above mentioned. The results are shown below:

Flag.	Number.	Gross Tonnage.	Percent of total.	Mean size.
Great Britain	266	1,303,333	48.6	4,900
Germany	93	592,549	22.1	6,371
United States	36	180,634	6.7	5,018
Italy	25	116,541	4.3	4,662
France	18	113,747	4.2	6,319
Holland	19	95,853	3.6	5,045
Norway	41	82,733	3.1	2,018
Denmark	9	53,191	2.0	5,910
Austria	8	31,164	1.2	3,897
Russia	5	29,316	1.1	5,863
Cuba	11	26,269	1.0	2,388
Spain	5	25,089	0.9	5,018
Belgium	4	24,802	0.9	6,201
Sweden	2	3,946	0.1	1,973
Brazil	2	3,710	0.1	1,855
Portugal	1	2,744	0.1	2,744
Total	545	2,685,625	100.0	4,928

Analyzing still further, with regard to sizes of ships engaged in this traffic, it is seen that the greater part of the British preponderance consists in vessels between 3,000 and 5,000 tons gross, there being 158 such ships, aggregating 636,767 tons, or an average of 4,030. This compares with 27 for Germany and 9 for the United States, under the same classification. When it comes to the largest size of ships, those above 10,000 tons gross, we find that Germany, with 23 vessels, has a lead over Great Britain, with 19. The British ships average larger, however, so that the German lead in tonnage is much less relatively than in numbers, there being 309,790 tons against 298,660 tons.

The total steamer movement in the "foreign trade" is seen to consist of ships from sixteen different nations. These might be placed under three different headings, so far as magnitude of operations is concerned. The British and German would constitute the first class; the American, Italian, French, Dutch and Norwegian are in the second class; while the other nine nations, none of which has steamers aggregating more than 60,000 tons gross engaged in this service, would form the third. The first class accounts for 359 vessels, aggregating 1,895,882 tons, or 70.7 percent of the total. The second class contains 139 vessels, aggregating 589,508 tons, or 21.9 percent of the total. The third class contains 47 vessels, amounting to 200,235 tons, or 7.4 percent of the total. It should be noted in this connection, of course, that the figures given bear no definite relation to the steamship entrances or clearances of the port, because no steamer is here included more than once, however many times she might enter or leave the port.

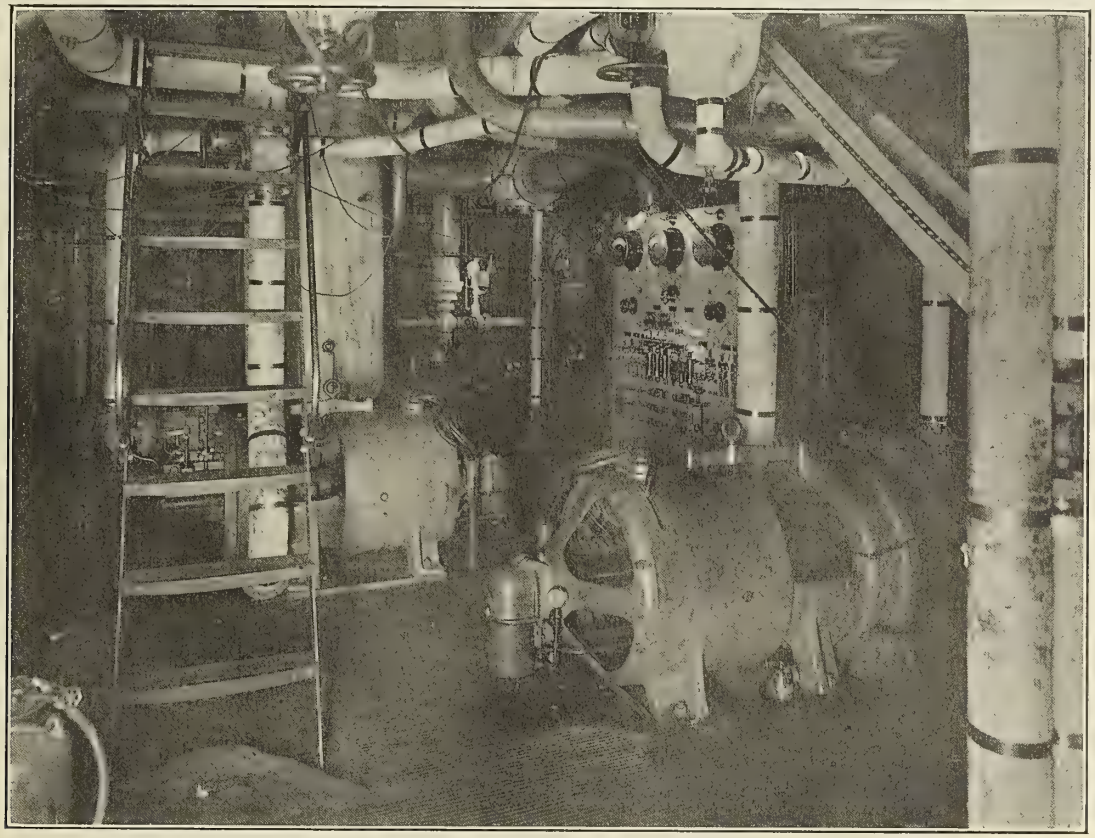


TWO-POLE 15-KILOWATT GENERATOR MOUNTED ON SHAFT WITH CURTIS STEAM TURBINE OPERATING AT 3,000 REVOLUTIONS PER MINUTE.

British Steamers.	Number.	Gross Tonnage.	Percent.	Mean size.
Under 3,000 tons	53	128,881	9.9	2,432
3,000 to 5,000 tons*	158	636,767	48.9	4,030
5,000 to 10,000 tons	36	239,025	18.3	6,640
10,000 tons and over	19	298,660	22.9	15,719
Totals	266	1,303,333	100.0	4,900
*3,000 to 4,000 tons	72	253,333	19.4	3,519
*4,000 to 5,000 tons	86	383,434	29.5	4,459
German Steamers.				
Under 3,000 tons	22	49,691	8.4	2,259
3,000 to 5,000 tons	27	104,770	17.7	3,880
5,000 to 10,000 tons	21	128,298	21.7	6,109
10,000 tons and over	23	309,790	52.2	13,469
Totals	93	592,549	100.0	6,371
American Steamers.				
Under 3,000 tons	12	26,324	14.6	2,194
3,000 to 5,000 tons	9	36,246	20.1	4,027
5,000 to 10,000 tons	10	59,340	32.8	5,934
10,000 tons and over	5	58,724	32.5	11,745
Totals	36	180,634	100.0	5,018

None of the Norwegian vessels exceeds 4,500 tons gross. Some of the other nations, however, are represented by large ships:

Tons	3,000 to 5,000	5,000 to 10,000	10,000 and over.
Italy	10 = 41,650	12 = 66,648	
France	4 = 14,660	9 = 55,279	3 = 38,497
Holland	2 = 7,666	2 = 14,835	4 = 52,457
Denmark	3 = 11,507	2 = 18,109	2 = 20,180
Belgium	3 = 12,784		1 = 12,018



25-KILOWATT HORIZONTAL CURTIS TURBINE SET IN ENGINE ROOM OF HUDSON RIVER STEAMER HENDRICK HUDSON.

Steam Turbines for Electric Boat Lighting.

Every modern steamer, whether for ocean travel, lake or river service, is now equipped with an electric light and power plant, not only for operating the incandescent lamps in the various cabins, state rooms and lounging rooms, as well as in the boiler room, engine room and every portion of the boat, but also to furnish current for electric motors driving auxiliary machinery, including ventilating fans, pumps and other apparatus, and on ocean steamers refrigerating installations as well.

Steam turbines have now been developed to such a state of perfection that they are employed in place of reciprocating engines, not only for driving the propellers of channel steamers, steam yachts, and river and lake boats, but also the largest ocean liners. For the electric lighting and power equipment of modern vessels steam turbines are also being utilized successfully, on account of the small space they occupy, the high efficiency obtained, and the low cost of installation and maintenance.

The steam turbine and dynamo room of the Hudson River Day Line steamer *Hendrick Hudson* is equipped with two horizontal Curtis steam turbines, directly connected to multipolar electrical generators supplying a current of 125 volts and 25 kilowatts capacity, and operating at a speed of 3,600 revolutions per minute.

Another illustration shows a 15-kilowatt Curtis turbine operating at a speed of 3,000 revolutions per minute and delivering a continuous current of 115 volts, the generator being mounted on the shaft with the turbine.

The 30-kilowatt bi-polar compound wound generator with Curtis non-condensing single stage steam turbine is very compact, occupying a space less than two feet in width, a trifle over two feet in height, and 64 inches in length. The speed of this outfit is 4,500 revolutions per minute, and it weighs 1,850 pounds.

The North German Lloyd has ordered an 18-knot passenger steamer, to be named *George Washington*. The dimensions are 720 by 78 by 54 feet, a draft of 33 feet, displacement of 36,000 tons and gross tonnage of 27,000. The engines will develop 20,000 indicated horsepower. The ship is intended to meet the needs of those who prefer comfort and elbow room to high speed.

Progress of Naval Vessels.

The Bureau of Construction and Repair, Navy Department, reports under date of May 10, 1907, the following percentage of completion of vessels building for the United States Navy:

	Tons	Knots		Apl. 1	May 1
BATTLESHIPS.					
Nebraska	14,948	19	Moran Brothers Co.	99.2	99.6
Mississippi	13,000	17	Wm. Cramp & Sons.	81.38	84.69
Idaho	13,000	17	Wm. Cramp & Sons.	73.66	78.11
New Hampshire	16 000	18	New York Shipbuilding Co.	64.7	67.9
South Carolina.	16,000	18½	Wm. Cramp & Sons.	9.38	11.21
Michigan	16.000	18⅛	New York Shipbuilding Co.	11.1	13.1
ARMORED CRUISERS.					
California	13,680	22	Union Iron Works.	99.6	99.6
South Dakota.	13,680	22	Union Iron Works.	97.1	97.4
North Carolina.	14 500	22	Newport News Co.	75.81	78.8
Montana	14,500	22	Newport News Co.	70.92	72.9
SCOUT CRUISERS.					
Chester	3,750	24	Bath Iron Works.	71.9	75.58
Birmingham	3,750	24	Fore River Shipbuilding Co.	67.4	70.3
Salem	3,750	24	Fore River Shipbuilding Co.	68.3	72.1
SUBMARINE TORPEDO BOATS.					
Cuttlefish	—	—	Fore River Shipbuilding Co.	91.5	92 5
Viper	—	—	Fore River Shipbuilding Co.	90.6	91.6
Tarantula	—	—	Fore River Shipbuilding Co.	92.5	93.5
Octopus	—	—	Fore River Shipbuilding Co	90.42	91.4

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The edition of this issue comprises 6,000 copies. We have no free list, accept no return copies and issue only enough to supply the regular demand.

Marine Propulsion.

Great changes usually operate slowly, but the last ten years have witnessed, along the line of power generation and the propulsion of ships, changes which have followed one another so rapidly as to make it difficult to keep pace with them. For ninety years the only mode of propulsion of ships, other than that furnished by the wind, was obtained through the use of reciprocating engines using steam as a motive power. Then suddenly there crept into notice a new form of prime mover, which, curiously enough, was only a development of the oldest form of which civilization has any record. In the little *Turbinia*, 100 feet long, a steam turbine was placed; and though the first few trials were sadly disappointing to those who had the matter in charge, yet the developments of the next two or three years were of such a startling character as to attract the attention of the entire engineering world. That was ten years ago.

About the same time there began to be developed, with some degree of success, the internal combustion engine. This was by no means a new thing, but it use for marine purposes was new. During the last four or five years, this form of motor has made gigantic strides into public favor, and now is used almost universally where engines of less than 300 horsepower are required.

The old reciprocating steam engine still continues to be built in enormous numbers, and this will be the case undoubtedly for many years to come. For certain special purposes, however, particularly when weight saving becomes of supreme importance, it will be gradually supplanted by one or the other of the two new forms of engine.

Much speculation has been indulged in with regard to the possibilities of gas engines using a fuel formed on shipboard by means of a producer gas outfit. Some success has been attained in small sizes with anthracite coal as the fuel. Anthracite, however, is expensive and difficult to obtain, in comparison with bituminous. More than this, it is found in only a few parts of the world; indeed, the Pennsylvania fields furnish a very large proportion of the entire world's output of this form of coal. Experiments are now under way looking to the use of bituminous coal in some form of producer, in such a way as to furnish the proper quality of gas for use in an internal combustion engine. Success along this line will be extremely far reaching in its possibilities, because bituminous coal of a good quality is to be had all over the world, and the quantity available is enormously greater than the quantity of anthracite.

There are four questions operating in the mind of the marine engineer when it comes to the fitting on shipboard of one or another of these forms of motors. The first question, and the one which is perhaps of supreme importance on shipboard, is that of weight. A second question is of only slightly less importance—that of space. The third question has relation fundamentally only to ships of war—and that is, smallness of target. This third question is tied up in a consideration of lowness of target, and in this way with lowness of center of gravity. From this point of view, the question becomes one of stability, and as such affects mercantile ships as well as warships. The fourth question is concerned with fuel consumption, and hence with economy of operation.

The subject of weight is one of the most vexing before the naval architect. On certain specified dimensions he has only a certain total allotment of weight, out of which must come the hull and all its fittings; the entire machinery plant and fuel; the equipment of the ship and the stores. In addition to this, a warship carries certain weights of battery and armor; while a merchant ship carries cargo and passengers. There is always a demand upon the designer to get everything down to the lowest possible weight consistent with safety. The requirements of the various departments are of an ever increasing nature, whether the structure be intended for naval or for commercial use. When, therefore, it is possible to make use of any device which, without detrimental features along other lines, and without increase in cost, will permit a considerable reduction in the weight allotted to this particular portion of the ship's entity, the naval architect

is quick to seize upon it, and to make the best use of it possible.

The watertube boiler was the first of the great weight saving appliances of recent years. This has been adopted exclusively in naval service, and, although its hold upon the mercantile marine is as yet but slight, it is certain that this form of steam generator must soon begin to supplant its older, heavier and more cumbersome rival. The steam turbine again offered advantages with regard to weight saving. The entire machinery plant of the *Turbinia,* which developed about 2,200 horsepower, represents a weight of only 22 tons. This gives 100 horsepower per ton, as compared with about 50 in the most approved type of reciprocating steam engines of similar size and design, for corresponding work. It is said that in larger sizes the turbine does not offer relatively so great an advantage in weight saving; but the fact remains that it does offer a considerable saving, and further that, being more flexible in operation than the reciprocating engine, it has a higher overload capacity, and hence can be relied upon with more certainty for giving extra power when needed.

The internal combustion engine offers little advantage over the reciprocating steam engine, so far as weight is concerned. As, however, it requires no boiler, it will be seen that the entire machinery plant has been very greatly reduced in weight. When it comes to a question of producer gas equipment, we have the producer to offset the boiler. But it appears that, for a given power, the producer would weigh much less than the corresponding boiler, and here again we have an advantage in weight.

By generating steam at a higher pressure, the watertube boiler furnishes power with a smaller demand upon space than is the case with the old cylindrical boiler. The steam turbine requires less space than the reciprocating engine of similar power, though the advantage in this case is mainly with regard to height. The gas engine offers little advantage in this respect except from the doing away with the boiler. The producer gas outfit permits some saving in space, as well as in weight.

When it comes to the reduction of the target and the lowering of the center of gravity of the steam outfit, there is not very much choice between the watertube boiler and the Scotch boiler, but what little difference does exist, lies perhaps in favor of the watertube type. The steam turbine, however, offers very great advantages in this direction, because its entire mass is centered around the shaft, and the height is consequently very much less than in the case of the reciprocating engine. Not only this, but the center of gravity is still further lowered on account of the absence of heavy cylinders in the highest portion of the engine. The gas engine, being usually quicker running that the reciprocating steam engine, has a shorter stroke for the same power, and is, therefore, a lower structure, with consequent advantages along the line of stability.

Consumption of fuel and economy in operation is the point where commercialism enters into the problem; and it is needless to say that this is the one point of supreme importance in all marine structures, except those devoted to warlike purposes. It is this question of economy which has kept the Scotch cylindrical boiler in use in commercial fleets long after it has been relegated to the past in warships. This is because the watertube boiler has not yet thoroughly demonstrated that it can be operated, year in and year out, at the same expense for fuel, attendance, repairs and general upkeep as can the tank boiler. Until it can compare favorably in this respect with its predecessor, it cannot hope to make very heavy inroads into the commercial field. Signs are not wanting, however, that it will be only a short time before these inroads begin in earnest.

For high speeds it seems to have been demonstrated pretty conclusively that the steam turbine is the peer, if not the superior, of the piston engine, so far as fuel consumption is concerned. Certainty and reliability of action are also not wanting, and it seems to be incontestable that the requirements of the turbine for attendance, and for such items as oil and waste, are far below those of its predecessor. For lower speeds, the turbine is not so well adapted.

With the gas engine we are confronted by a different sort of a proposition. Thorough reliability does not yet appear to have been reached in most types. The question of economy of operation can here be measured only by monetary comparisons, because of the radically different characters of the fuels employed. With the producer gas outfit, however, we again have coal compared with coal; and with the two grades of coal equally expensive the comparison could be made direct, by taking account of the number of pounds of fuel used for a given return in horsepower hours. When the bituminous producer becomes an accomplished fact this sort of comparison can be made. At present, however, it is necessary to take account of the different grades of coal, and the prices at which they can be bought. Even with a disadvantage of this sort against it, however, the producer outfit, in such small installations as have yet been placed upon the market makes a splendid showing, and further advances are to be looked for in the future.

The article beginning on page 282 takes up a part of these questions from the point of view of the purely war-machine. It has not yet been seriously proposed to fit such an installation as that suggested, but the idea is fascinating, and it wants only demonstrated success on a large scale to get the project actually under way.

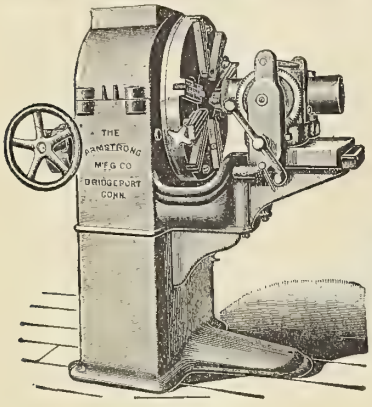
The Bermuda Races.

Our congratulations are due, not alone to the winners, but to all the participants of the recent New York-Bermuda races of yachts and motor boats, for having given evidence anew of the value of soundness in design and ruggedness in operation.

ENGINEERING SPECIALTIES.

Improved Pipe Threading and Cutting Off Machine.

Combination of effects, and proper proportioning of weight and strength of the mechanical means to the effects, are the two factors which have most powerfully contributed to the present unquestioned universal supremacy of American machines and machine tools. These qualities are well illustrated in the improved Armstrong pipe threading and cutting off machines. Of tools which will cut a thread on a piece of pipe, and then allow the pipe to be slipped through to the proper length and cut off, there are many. None, however, excel this design in compact-



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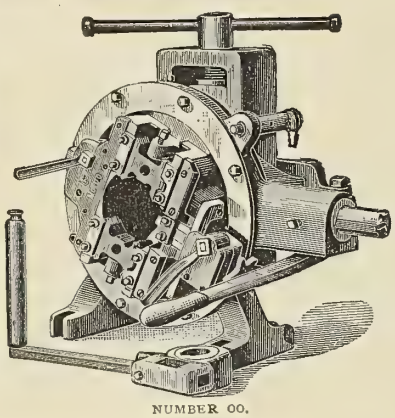
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ness and strength in proportion to the weight. The machines are built in five different sizes of large range, from No. 0, taking from ¼ to 2-inch pipe, and weighing 135 pounds, with dies, cutting by hand or power; up to the 1,250-pound power machine No. 3, which cuts and threads pipe from 1 to 6 inches inclusive. They are also available for threading bolts, the No. 0 machine taking bolts from ½ inch up to 1½ inches in diameter, and thus making a combination thread and bolt machine.

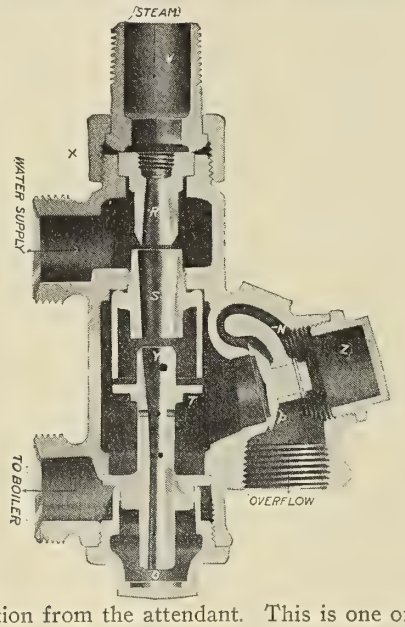
Pipe is gripped in a powerful, self-centering vise, secured by lugs to a post, bench or any temporary support in case of Nos. 0 and 00, and permanently built into the stand in the larger sizes, Nos. 1, 1½ and 3. Immediately in front of the vise is the die head, carrying a machine counterpart of the Armstrong adjustable stock for hand threading, the die being divided into from two to eight sections, according to the size of pipe. In the two-jawed dies adjustment is made by individual end screws, but in the larger sizes, turning a single screw moves all the die sections simultaneously. The die head has no gear teeth on the part coming in contact with the shell, while a generous bearing insures firmness and little wear. In No. 0 machine there is a geared spindle in addition to the main driving spindle, so that two speeds are provided, enabling small pipe to be threaded very quickly when the handle is on the main spindle, and giving less speed and more power for pipe from 1¼ to 2 inches by changing the handle to the geared spindle.

These machines will thread and cut off a quarter-inch pipe in two and one-half, and a six-inch pipe in four minutes, with proportionate time for intermediate sizes. All the gears and bearings being inclosed in a dustproof oil chamber, perfect lubrication is insured, as well as perfect protection from dust, dirt and metal chips.

The compactness, simplicity, small weight, and thorough workmanship of the machines has won for them a very large and increasing market. All sizes up to No. 00, which will cut 4-inch pipe, can readily be moved to outside work, and be easily taken in and out. Work beyond 4 inches is not found in ordinary outside jobs. Owing to special labor saving machinery and long experience in manufacture, the Armstrong Manufacturing Company, of Bridgeport, Conn., has been able to place these machines within the reach of anyone having sufficient work to warrant their use.

The Penberthy Automatic Injector.

This is said to be a perfect re-starting automatic machine. By this is meant that when the injector is working, if the current of water be suddenly interrupted, as is liable to happen from a sudden jar or jolt (on such apparatus as traction engines or road rollers, or in the case of a marine boiler, by the rolling of the vessel) this injector will automatically re-establish the current

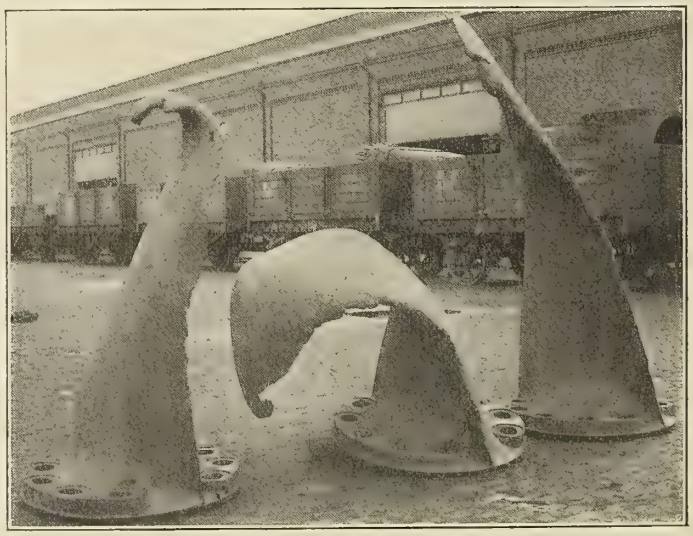


without attention from the attendant. This is one of the features that has given the Penberthy a hold among marine engineers and traction and threshing engine manufacturers.

The Penberthy is so constructed as to have but few wearing parts, and will last for years with proper care without renewals. All parts are interchangeable, however, when required. It is placed on the market by the Penberthy Injector Company, of Detroit, Michigan.

Damaged Propeller Blades.

These propeller blades were taken by the salvage company off the steamship *Yeoman* of the Harrison Line, which was wrecked off the Spanish coast. The photograph shows the tenacity of the bronze used in the manufacture. The blade that is most



bent was at the bottom when the ship settled down, and the whole weight of the vessel was on this blade. When, however, it was taken away, there was no sign of a fracture in it.

The manufacturers of this propeller were Messrs. Billington & Newton, Limited, Longport, Staffordshire.

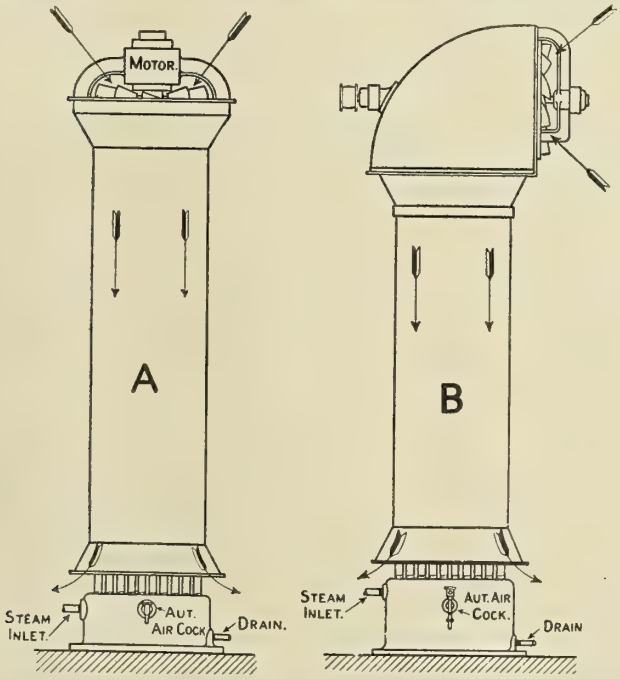
Electric Marine Heaters.

A line of electric stoves is being placed upon the market by O. C. Hawkes, Limited, 69 Aldersgate street, London, E. C., which are reported to be of splendid economy. The interior temperature is from 400 to 600 degrees Fahrenheit, with a current consumption amounting to 500 watts, or ⅔ horsepower. A stove of this size is said to have raised in fifteen minutes the temperature of a cabin 10 by 10 by 8 feet, through a range of 10 degrees

Fahrenheit. A certain amount of circulation is obtained, because the air drawn in at the bottom is emitted at the top of the stove at a high temperature, resulting in the heat's being evenly distributed. Heat is generated by resistances other than the ordinary lamps, and it is said that there is nothing fragile to get out of order. As all the electric connections are provided with lock nuts, the vibration of the ship has no bad effect. The stoves are compact, strong and well protected against the usage they will meet on shipboard.

Stanlock Ventilators.

The Standard Engineering Company, Limited, 43 Welford Road, Leicester, has developed a type of ventilator and heater for factory and ship use, in which a unit 18 inches in diameter and 7 feet high is used. This is fitted with a fan, which may be operated either by a belt with outside power or by a small electric motor contained within the apparatus. Each unit is said



to circulate 2,000 cubic feet of air per minute, and to condense 100 pounds of steam per hour when used for both ventilating and heating. The power absorbed is said not to exceed ⅛ horsepower, and as overhead air pipes are dispensed with, a very considerable economy is claimed. The units are composed of solid drawn steel tubes, tested to a pressure of 300 pounds per square inch, and for heating can be used with either exhaust steam or steam at a pressure of 60 pounds or more.

A New Line of Watertight Bells.

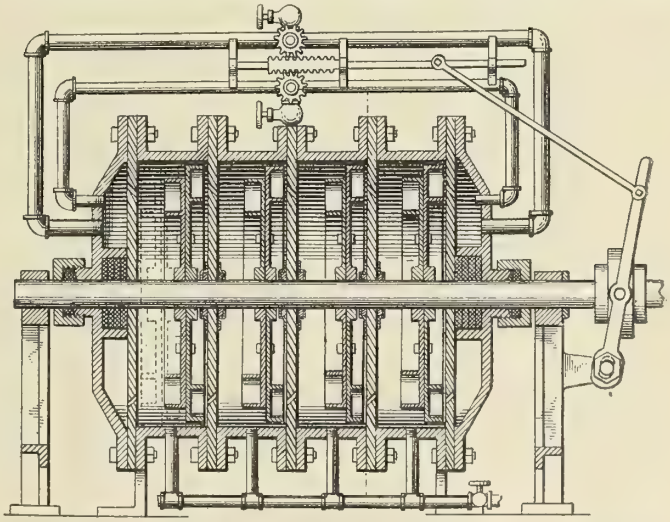
The illustration shows one of the new watertight electric vibrating bells which have been recently developed by the Holtzer-Cabot Electric Company, Brookline, Mass. These bells have been especially designed to meet the exacting requirements of the United States navy and of marine service in general. The operating mechanism is constructed along new lines and is entirely inclosed in an absolutely watertight case. Connections may be piped in through the top of the case, or led in through a special

stuffing box. These bells will operate on battery circuits, or on voltages from 6 to 220, without external resistance, and without sparking at the platinum contacts.

Under ordinary conditions the current consumption is less than 1/10 ampere. The gongs are furnished in sizes ranging from 3 to 14 inches, are made of heavy bell metal of the best quality, and are securely fastened to prevent working loose. The finish of the bells may be either black Japan or black oxidized copper. This type of bell will stand up under the most severe tests, and give general satisfaction wherever installed.

A New Steam Turbine.

A reversing turbine, designed primarily for marine use, has been patented by Karl P. Hangl, 4 Brown Place, New York City. A small model of this turbine, having a 5-inch wheel, has been



brought up to a speed of 4,000 revolutions per minute, and then reversed in 3½ seconds by the simple expedient of changing the direction of the flow of steam from one side to the other. The flow of the fluid under pressure is partially axial and partially

transverse, the angle of incidence being about 45 degrees. The illustration shows that two opposed sets of buckets are mounted back to back upon the shaft, and it will be seen that when one set is receiving steam the other will be revolving with it; while when the steam is shut off from the first set and applied to the second in the reverse direction, the rotation will naturally be reversed. The illustration shows also how several successive sets of buckets are arranged within the single casing.

One of the important features of this motor is the large fluid chamber in which each turbine or piston rotates, and the means for regulating by hand the area of the exhaust. Another feature is the means of shifting the rotary piston with its double ring of blades for reversing, the dotted lines at the left end of the drawing showing the position assumed under such circumstances. It has not yet been feasible to make an economy test on this turbine, experiments up to date having been directed solely to the question of complete reversibility.

The use of such a turbine would in effect substitute the idle buckets, as shown, for the idle "astern" turbines in present installations, with a probable considerable decrease in weight and complexity of parts, as well as in space occupied; while the reversing power could easily be made fully equal to that for going ahead, in place of being only a small fraction of the direct power, as at present in vogue.

TECHNICAL PUBLICATIONS.

Practical Engineering: A Comprehensive Treatise on Steam Machinery and Apparatus, Compressed Air, Refrigerating Machinery, Hydraulic, Elevating, Gas and Oil Engines, Turbines, etc. Edited by Carl S. Dow, S. B., assisted by expert mechanical engineers. Size, 6¾ by 9½ inches. Pages, 2,248+88, in three volumes. Illustrations, about 2,500. 1907: Philadelphia, The American Text Book Company, and the Historical Publishing Company. Price per volume, bound in three-fourths Russia, $5 (£1-0-6).

Volume I is divided into fourteen chapters, as follows: Mechanical Engineering; Types of Boilers; Boiler Fittings; Heat; Fuels and Combustion; Draft; Mechanical Stokers and Economizers; Construction and Design of Boilers; the Boiler Shop and Layout of Plates; Corrosion, Incrustation and Boiler Explosions; Setting and Testing Boilers; Pipe Fitting; Warming Buildings; Operation and History of the Steam Engine. This volume comprises 714 pages.

The second volume is divided into thirteen chapters, covering respectively: Steam Engine Accessories; Valves and Valve Gears; The Steam Engine Indicator; Types of Engines; The Steam Turbine; Coal and Ash Conveyors; Management and Testing of Steam Engines; Steam Power Plants; Pumping Machinery; Hydraulics; Hydraulic Elevators; Marine Boilers and Engines; and Crude Oil as Fuel. This volume comprises 761 pages.

The third volume contains ten chapters and the 29-page index to the complete work. The chapters cover respectively: Resistance of Ships; Locomotive Engines and Boilers; Air Brakes; Compressed Air; Gas and Oil Engines; Refrigeration; Questions and Answers for Stationary Engineers; Questions and Answers in Marine Engineering; in Locomotive Engineering; and Practical Electricity. This volume comprises 800 pages of text.

These works have been prepared in as simple as possible a manner consistent with accuracy, and are thoroughly up to date. They have been written to give the operating engineer an opportunity to study the essentials of mechanical engineering in detail, as well as in a broad way; to enable him to become acquainted with branches other than his own, and to prepare for new responsibilities.

The sections in which we are especially interested are those relating to marine boilers and engines in the second volume; and to resistance and propulsion, and queries and answers for marine engineers, in the third volume. The questions were prepared largely from the pages of this journal, they being a selected list comprising as well as possible all branches of the subject. The text matter covering marine engines and boilers takes up the subject in general, without going very deeply into detail. It is rather a résumé of the subject than a treatise upon it. It is, however, entirely up to date, and gives a good general idea of the scope of the subject as a whole.

The subject of resistance and propulsion is taken up in logical order, the resistance of ships including a discussion of wetted surface, stream lines, wave making resistance and eddy resistance. Then the laws of mechanical similitude and of comparison are discussed, and also causes affecting the resistance, such as change of trim, shallow water and a foul bottom. Propulsion is considered under the headings of towing, sailing, hydraulic propulsion, paddle wheels and screw propellers, nearly all of the discussion of course covering the latter subject. This discussion covers the geometry of the propeller, interaction between the propeller and the ship, considerations of wake, slip and cavitation, and a description of the screw turbine. Propeller design is also given attention. The subject of power is taken up from independent estimates, the law of mechanical similitude, and from the point of view of the Admiralty coefficient, concluding with a discussion of speed trials.

Directory of Shipowners, Shipbuilders and Marine Engineers, 1907. Size, 5 by 8½ inches. Pages, 692. Directory Publishing Company, 3 Ludgate Circus Buildings, London. Subscription price, 5/-, after publication, 10/-.

This is a very well compiled directory covering the whole of the industry, as its title implies; it is certainly very conveniently arranged, and the indexes, of which there are several, are quite a special feature of the book, facilitating reference to every detail in the volume. Apparently great care has been taken to make the directory as useful as possible, and it certainly serves the purpose of being a thorough guide to who's who, and what's what, in the shipowning and shipbuilding world.

Bureau Veritas: Rules and Regulations for the Building and Classification of Sailing Yachts, Wood, Composite and Steel. Size, 9¼ by 7½ inches. Pages, 132. 1907: The Bureau Veritas, 8 Place de la Bourse, Paris; 155 Fenchurch street, London, E. C.; 17 State street, New York. Price, $1.50 (6/-).

This work covers rules up to date compiled to meet the demands of yachtsmen and yacht builders, with due regard to international rating and classes. It covers the subject of sailing yachts of all characters from ratings of 5 meters (16.4 feet) to 23 meters (75.4 feet) and takes up the subject in their regular method for designating the scantling members of vessels. It is provided with the usual tables, giving sectional areas and other dimensions required under the several classifications of members of the hull, while the equipment is given adequate treatment in other tables and sections of the rules.

In addition to the rules and tables, there is given a complete directory of the Bureau Veritas, including the administrative departments and the surveyors and agents all over the world. The latter are grouped geographically. A complete index makes the work very handy for reference.

Shipbuilding at Nagasaki.

The Mitsu Bishi Dock Yard & Engine Works of Nagasaki had a very prosperous business in 1906. The workmen numbered 8,946. Many important additions and extensions to the facilities of the yard were required, among the most notable improvements being the building of large shops to manufacture marine steam turbines and turbo generators.

During the year there were built six steamers, four torpedo boat destroyers, and one steel caisson for a dry-dock. The steamers aggregated 12,890 tons gross, and 12,449 horsepower. At the beginning of 1907 there were under construction a destroyer and a dispatch boat for the Japanese government, and seven steamships of an aggregate of 64,340 gross tons.

QUERIES AND ANSWERS.

All reasonable questions concerning marine engineering received from and signed by subscribers will be answered by the Editor in this column. All communications must bear the name and address of the writer.

Q. 379.—For an amateur designing a launch would not the following method be a good check on drawing and figures, also an accurate way of determining the form of boat to give the best results?

Take for example a launch 35 feet over all. Construct a full model on any convenient scale, say ¾ inch to the foot, which would be one-sixteenth actual size, making the model 26¼ inches over all. If the weight of the model equals one-sixteenth of the weight of the hull and house of the actual boat, and weights of lead or iron be placed in the model in their respective positions to represent the engine, propeller, rudder, fuel, etc., would this show sufficiently accurately the way the boat would set in the water?

(2) In towing models through the water of a tank to determine the best form of lines, where is the pull applied on the model? F. C. F.

A.—If you make your model on a scale of ¾-inch to 1 foot, or one-sixteenth size, the weight of the model will be not one-sixteenth the weight of the hull of the actual boat, but the cube of one-sixteenth or 1/4096. In other words: if it should happen that the boat itself weighs 20,480 pounds, then the model should weigh 5 pounds, in order to be immersed in water to a corresponding draft. Each of these figures might be assumed to be the final weight, with all machinery and everything on board.

If the weight of the model is correctly proportioned to the weight of the hull of the boat, then small weights of lead or, as is sometimes convenient, sand or shot, could be placed in the model in proper position to represent the engine and other weights which the boat would carry; and if these weights were accurately figured with regard to weight, and accurately placed in the model, then the resulting trim of the model ought to show what might be expected in the boat.

(2) The pull is usually applied at a point between the bow and the stern of the model, and distant from the bow about one-fifth the length of the model. Means should be applied so that the direction of this pull would be uniformly *forward*, and that there should be no constraint in a vertical direction. This is due to the fact that a model in running follows the performance of the boat in running, in that it assumes a trim to suit its form, and the conformation of the waves which its motion sets up.

In towing models, it is well to remember that the speed of the model is related to the corresponding speed of the boat as the square roots of the respective lengths. For the case in question, the length ratio is 1 to 16; the speed ratio would therefore be 1 to 4. A speed of four miles per hour with the model would represent a speed of sixteen miles per hour with the boat.

Q. 380.—The question came up some time ago to design a Scotch marine boiler with the following dimensions: inside diameter of shell, 144 inches; length over all, 144 inches; working pressure, 125 pounds; longitudinal seams to be butt jointed with straps in and outside, and triple riveted; tensile strength of shell to be 60,000 pounds.

Rule for thickness of cylindrical shell according to United States Inspection Law:

Multiply one-sixth of the lowest tensile strength found stamped on any plate in the cylindrical shell by the thickness—expressed in inches or parts of an inch—of the thinnest plate in the same cylindrical shell, and divide by the radius or half diameter—also expressed in inches—and the result will be the pressure allowable per square inch of surface for single riveting; to which add 20 percent for double riveting, when all the rivet holes in the shell of such boiler have been "fairly drilled" and no part of such holes has been punched.

Now 1/6 of the tensile strength for single riveting + 20 percent for double riveting is

$$1/6 + 1/6 \times \frac{20}{100} = \frac{1}{6} + \frac{20}{600} = \frac{1}{6} + \frac{1}{30} = \frac{5}{30} + \frac{1}{30} = \frac{6}{30} = \frac{1}{5}$$

Then, according to the United States rule, there would be one-fifth (1/5) of the tensile strength for double riveting.

Then, a shell ¾ inch thick would be suitable for

$$\frac{60,000 \times 0.75}{5 \times 72} = 125 \text{ pounds.}$$

According to the inspector's figuring, this boiler would be permitted only 124 pounds, his figuring being as follows:

$$\frac{60.000 \times 0.75}{6 \times 72} = 104.16666666666 + . + .$$

20 percent of 104.16666666666 = 0.2 20.83333333333 + . + .

124.99999999999 + . + .

As the inspectors do not allow for any fraction, this boiler is allowed only 124 pounds steam pressure instead of 125 pounds, as should be mathematically, according to United States rule.

Another way of figuring, so as to follow the United States rule exactly, is as follows:

$$\frac{60,000 \times 0.75}{6 \times 72} = 104\ 1/6 = 104\ 5/30$$

20 percent of 104 = 20 8/10 = 20 24/30

20 " " 1/6 = 1/30 = 1/30

144 30/30 = 125 pounds

Please let me hear your opinion in this particular case. I. J.

A.—The inspector who gave the figuring quoted has given another example of the sort of "pig headedness" developed by official red tape. The figuring as worked out originally, showing the boiler suitable for a pressure of 125 pounds per square inch, is absolutely correct, as is shown in the last calculation given. If a little more attention had been given by the inspector to the actual facts of the case, and a little less to the idea that the thing would have to be figured out in just one way and no other, his result would have agreed with that given by our correspondent. Again, if his decimals had been carried out to their actual limit—a proposition without possibility, and interesting only from an academic viewpoint—he would have obtained the same correct result, viz., 125 pounds per square inch.

Obituary.

John A. Walker, vice-president and treasurer of the Joseph Dixon Crucible Company, died May 23. He was born in New York, September 22, 1837, and became connected with Joseph Dixon & Company in 1867. His life has since been successfully devoted to the exploitation of graphite.

SELECTED MARINE PATENTS.

The publication in this column of a patent specification does not necessarily imply editorial commendation.

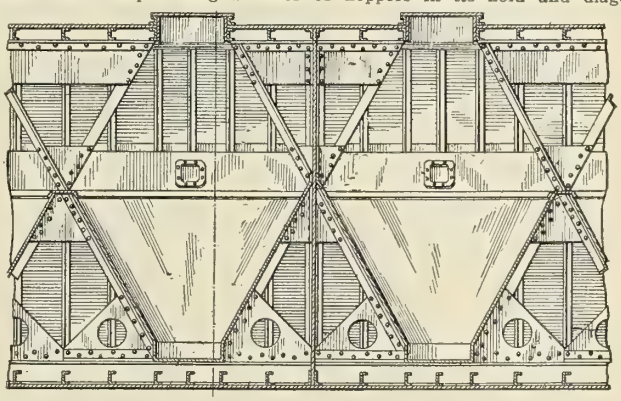
American patents compiled by Delbert H. Decker, Esq., registered patent attorney, Loan & Trust Building, Washington, D. C.

847,320. FOLDING MUSHROOM ANCHOR. CHARLES E. CRANE, LAKE CITY, MINN.

Abstract.—It is the object of this invention to provide a mushroom anchor arranged with a jointed shank, so that the bowl of the anchor may be folded in juxtaposition with the shank, so that the anchor may be conveniently stored upon the deck of the vessel, or slung alongside in the usual manner of slinging anchors; and to provide such a mushroom anchor that it may be laid upon the deck of the vessel and will not move upon the periphery of the bowl, to damage the vessel and articles upon the deck. Three claims.

847,677. SHIP CONSTRUCTION. GEORGE W. MAYTHAM, BUFFALO, N. Y.

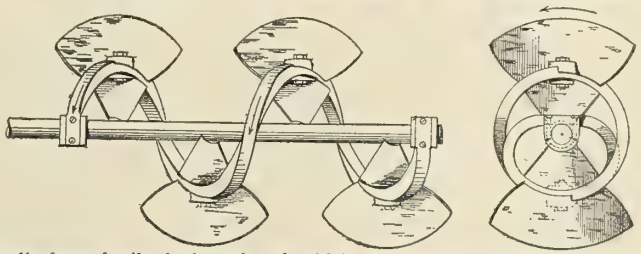
Claim 1.—A ship having a series of hoppers in its hold and diagonal



bars extending from the bottom of the hold to the deck on which the inclined sides of the hoppers are supported, said bars being arranged in pairs and the bars of each pair being inclined in opposite directions. Nine claims.

847,961. PROPELLER WHEEL. JOSEPH DE LA MAR, NEW YORK.

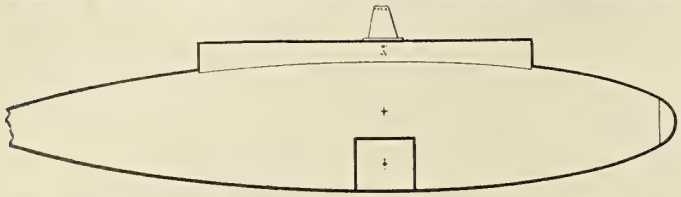
Claim 1.—A propeller wheel, comprising a shaft having thereon a



spirally-formed rib, both ends of which are rigidly secured thereto, and having blades thereon. Eight claims.

848,872. SUBMARINE OR SUBMERGIBLE BOAT. THEODORUS S. BAILEY AND LAWRENCE Y. SPEAR, QUINCY, MASS., ASSIGNORS TO ELECTRIC BOAT COMPANY, BAYONNE, N. J., A CORPORATION.

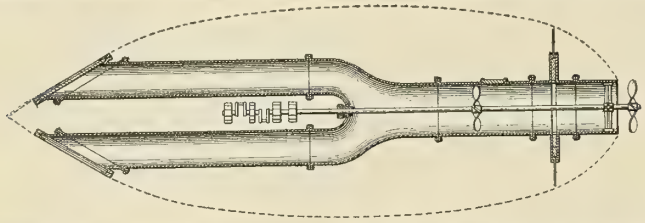
Claim 1.—A submarine or submergible boat having a submergence-tank, the center of volume of whose contents is substantially in vertical aline-



ment with the center of buoyancy of the immersed portion of the boat, said boat having a buoyant chamber so constructed and located that the centers of all water-planes passing therethrough shall lie substantially in a vertical line passing through the center of volume of the contents of said submergence-tank. Six claims.

848,457. BOAT PROPULSION. HARRY E. GRACE, BALTIMORE, MD., ASSIGNOR OF ONE-HALF TO THOMAS F. FITZBERGER, JR., BALTIMORE.

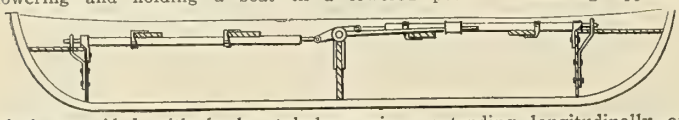
Claim.—A boat having a water flume or passageway extending fore and aft therethrough and having the forward portion of said flume branched to form starboard and port forks which open out through the bow of the boat and leave an intervening engine-space, closures for the forward and rear ends of the flume and branches thereof, a propeller-shaft extending through the stern portion of the flume, and a plurality of propellers



mounted on said shaft, one operating within the flume and the other in rear of the discharge end of the flume, the rear closure being located between said propellers, substantially as described. One claim.

848,998. BOAT LOWERING AND DETACHING APPARATUS. OLE P. E. KNUDSEN, SEATTLE, WASH.

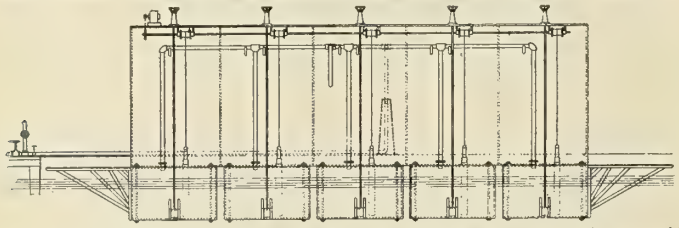
Claim 1.—An apparatus for launching boats comprising means for lowering and holding a boat in a lowered position including opposite



blocks provided with hooks, tubular casings extending longitudinally of the boat and being arranged adjacent the seats so as to serve as handholds, rods slidable in said casings and projecting from the outer ends thereof, the hooks of said blocks being engaged with the projecting end portions of said rods, and means for sliding said rods simultaneously. Two claims.

849,378. FLOATING DRY-DOCK. WILLIAM T. DONNELLY, BROOKLYN, N. Y.

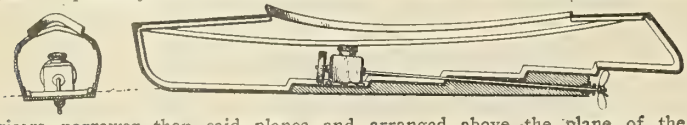
Claim 1.—In a floating dry-dock water-inlet means, unrestricted water-outlet means, means for supplying air under pressure to the various com-



partments and means for controlling the expansion of the air in said compartments while the dock is rising, substantially as described. Twenty-five claims.

850,034. BOAT. URIAH R. MILLER, SALEM, OHIO.

Claim 1.—A boat having its bottom provided with a flat forward portion and a plurality of transversely-inclined planes connected together by



risers narrower than said planes and arranged above the plane of the forward portion. Seven claims.

850,643. APPARATUS FOR TRANSPORTING AND LAUNCHING BOATS. JOHN J. HARPAIN, OF THE UNITED STATES NAVY.

Abstract.—The invention relates to apparatus for transporting submarine torpedo boats, so that they may be readily launched at sea whenever desired; and it also relates to means for securing said boats while in transport, and to means for supplying said boats with automobile torpedoes and for storing said torpedoes in a safe and available position.

A vessel equipped to carry submarine boats is so arranged that these boats may be carried in closed chambers, and the chambers may be flooded and the boats moved in or out by their own motive power. When the vessel is equipped to carry torpedo boats, torpedo magazines adjoining the chambers are provided, in which are placed a number of torpedoes, and these magazines are so arranged that the torpedoes may be conveniently released and attached to the exterior of the submarine boat. Twenty-nine claims.

British patents compiled by Edwards & Co., chartered patent agents and engineers, Chancery Lane Station Chambers, London, W. C.

24,225. PROPELLING AND STEERING SHIPS. A. J. DUDGEON.

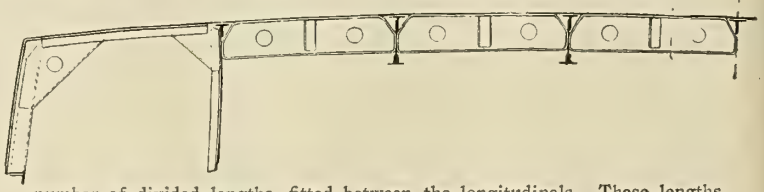
Two or more valves, operated by a lever so that when one valve is opened the other is closed, control the turbines propelling a ship. Lost motion is provided, to insure the closing of the valves when the lever is in the central position. An arrangement of three turbines is described. In forward running, the steam from the center turbine is led to the side turbines. In maneuvring, only the side turbines are used. The valves are operated by a lever and hand-wheel against the action of springs. On opening one valve, steam passes to the center turbine. On closing this valve and opening the other, steam passes to the side turbines. These turbines are controlled by piston valves, which may be operated by a starting-engine. Two sets of lift valves are provided, one for each side turbine.

24,460. CONDENSER. D. A. QUIGGIN.

Relates to condensers for the exhaust from the auxiliary engines on board ship, being particularly applicable to turbine steamers. The condenser is fitted with two stacks of tubes, through the upper of which the main feed is circulated, the lower being supplied with a regulable amount of seawater to complete the condensation, and to cool the water of condensation sufficiently to allow of efficient filtration before mixing it with the main feed. The heated condensing water may be employed to supply baths or the like. A perforated division plate may be fitted between the compartments, and baffle plates to prolong the path of the steam.

25,384. SHIPS' FRAMES AND FRAMING. PALMER'S SHIPBUILDING AND IRON COMPANY, AND A. E. LONG.

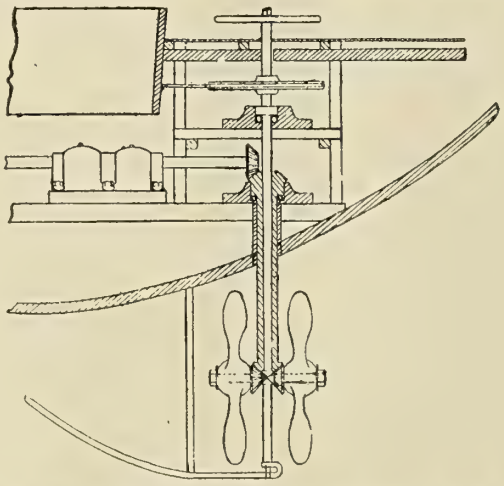
The longitudinal deck girders are made completely continuous, and not notched over the deck beams. The transverse beams are made up of a



number of divided lengths, fitted between the longitudinals. These lengths may either be made up of flanged plates, or of partially-flanged plates secured by angles. The camber of the deck is an arc of a circle, and the girders are set radially, so that all the divided lengths are of the same size. The separate tranverse beam pieces are stiffened by longitudinal pieces. The deck plating is made flush, so that it may be better adapted for covering with corticine.

25,486. PROPELLING AND STEERING SHIPS BY SCREW PROPELLERS. S. W. JENNINGS.

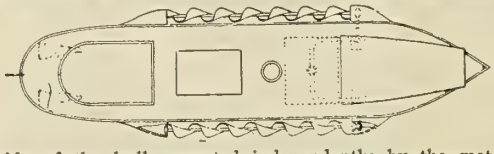
The main shaft of a motor boat or other vessel rotates two oppositely pitched propellers by means of bevel gearing through an intermediate hollow shaft. The propellers are carried upon a shaft, rigidly connected



to a vertical spindle, which passes through the hollow shaft and bears at its lower end upon a bracket, and near its upper end upon ball bearings. At the upper end of the spindle is a sprocket wheel, connected by a guided chain to a similar steering wheel secured by ratchet gear in the front of the vessel, and to an additional steering wheel, in case the other gear is disabled. The hollow shaft also rests in ball bearings and passes through a short sleeve to avoid leakage. By turning the spindle, the propellers can be moved at any angle to the axis of the vessel, causing the vessel to turn or even to be driven backwards, without reversing the engine.

27,166. SCREW PROPELLERS. R. SCHUBERT AND A. BARTH.

Motor boats and other vessels are fitted with long helicoidal propellers



on each side of the hull, operated independently by the motors through gearing. The propeller surfaces may either be inclined or at right angles to the axis of rotation. In conjunction with these propellers, two other propellers are fitted at the stern of the vessel, comprising inclined helical blades mounted upon conical bosses.